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PHILOSOPHICAL
EXPERIMENTS.

PHILOSOPHICAL
EXPERIMENTS:

March 29, 1739.

Imprimatur,

HANS SLOANE Pr. Reg. Soc.

PHILOSOPHICAL EXPERIMENTS:

CONTAINING

Useful, and Necessary INSTRUCTIONS for such
as undertake long Voyages at Sea.

Shewing how SEA-WATER may be made
FRESH and WHOLSOME: And how FRESH-
WATER may be preserv'd Sweet.

How BISCUIT, CORN, &c. may be secured from
the Weevel, Meggots, and other Insects.

And FLESH preserv'd in hot Climates, by SALTING
ANIMALS whole.

To which is added,

An Account of several Experiments and Observations
on CHALYBEATE or STEEL-WATERS: With some
Attempts to convey them to distant Places, preserv-
ing their Virtue to a greater Degree than has
hitherto been done.

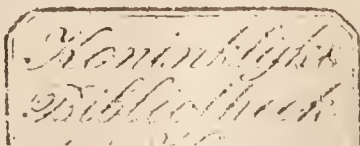
Likewise a Proposal for cleansing away Mud, &c.
out of Rivers, Harbours, and Reservoirs.

Which were read before the ROYAL-SOCIETY, at
several of their Meetings,

By STEPHEN HALES, D. D. F. R. S.
Rector of *Farringdon* in *Hampshire*, and
Minister of *Teddington*, *Middlesex*.

L O N D O N:

Printed for W. INNYS and R. MANBY, at the West
End of *St. Paul's*; and T. WOODWARD, at the
Half-Moon between the *Temple-Gates*, in *Fleet-
Street*. M.DCC.XXXIX.





T O

*The Right Hon^{ble} Sir CHARLES
WAGER, Kn^t*

Sir THOMAS LYTTLETON, Bar^t.

Sir THOMAS FRANCKLAND, Bar^t.

THOMAS CLUTTERBUCK, Esq ;

*The Right Hon^{ble} the Lord WILLIAM
POWLET.*

JOHN CAMPBELL, Esq ;

*The Right Hon^{ble} the Lord VERE
BEAUCLERK.*

Lords Commissioners of the
Admiralty.

MY LORDS,

THE following Treatise being
intended chiefly for the use
of Seafaring Persons, I am
naturally led to address my self to
A those

ii The D E D I C A T I O N.

those who are at the Head of, and have the Direction and Transacting of the maritime Affairs of far the most numerous and Powerful Fleet in the World.

It was to some of Your Lordships to whom I had the Honour of first communicating my Intentions of engaging in these Researches, which you were pleased to encourage me to pursue: That we might, if possible, find a never-failing Spring of fresh Waters in the midst of the *Ocean*.

I must confess I was at first much discouraged, when I reflected on my Rashness, in venturing on an Undertaking, which had baffled the repeated Attempts of the ablest Philosophers and Chymists, both Ancient and Modern: In so much that they looked upon it as almost impracticable

cable to find out any way to procure a wholesome Drink from Sea-Water. In which yet I have succeeded far beyond what I could have expected ; having found means not only to free distilled Sea-Water, from its nauseous bitter Oily Bitumen ; which made it most disagreeable to drink ; but also from another very hurtful Quality, *viz.* the Spirit of Bittern Salt, which is apt to arise in great plenty in Distillation ; but is now happily found to be detained from rising up by the same means, that the nauseous bitter Oily Bitumen is prevented from rising.

I hope also that the Method here proposed to keep fresh Water sweet will be of some service ; which tho' no new Discovery, yet has hitherto, as far as I can learn, been but little put in practice by the *English*, from

a fear they have had of hurting themselves, by such acid burning Spirits; and this they had great Reason to fear, when they knew not in what Proportion such acid Spirits might with safety be mixed with Water.

As to the Method proposed to prevent by the Fumes of burning Brimstone, Sea-Biscuit and Corn from being Eaten by Weevels, Meggots, &c. I am informed by several Seafaring Persons, many of whom I have consulted during the progress of these pursuits, that this would be of all others most Beneficial and Useful if it prove effectual. I hope therefore that those whom it most concerns, will, from the Hint I have here given, try various Methods and Degrees of Fumigation, till they have fully effected the thing; which I make

The D E D I C A T I O N. V

no doubt will so far succeed, as to be of very great Benefit.

Astoth Salting of Animals whole, this will doubtless be of considerable service, to furnish Ships with well-salted Flesh in hot Climates: 'Tis Experience must bring the thing to farther perfection, as to the Degree of Salting in due proportion.

It would be of considerable use towards our farther improving in the several ways here proposed for the Benefit of Seafaring Persons, if they would communicate from time to time, either what Difficulties they have met with, in the Execution of these things on the one hand; or, on the other hand, what Benefit and Advantage they have found thereby, as also what farther Improvements they have made; these all laid together and communicated to the

Publick, will be a farther Benefit to Mankind : especially to that important and valuable part of Mankind, who *see the Wonders of the Lord in the Deep* : And who are, under the guidance of Providence, not only our Chief Defence and Security ; but also the adventurous and industrious Instruments, by which the several and most distant Nations of the Earth carry on an extensive Commerce and Intercourse with each other ; which tends not only to the greatly enriching, but also to enlarging the Minds of Mankind, and to the Civilizing and Improving of them, by the Communication of mutual Benefits.

I have here also added an Account of some Experiments on Steel-Waters, which tho' it may not, in the main Design of it, be thought so proper
to

to join to a Treatise, which is chiefly intended for the use of Seafaring Persons, yet neither will it be wholly useless to them ; since they may hereby be informed, how to preserve for their use in a Voyage, the Virtue of Steel-Waters, which they shall any where meet with : And such Waters will doubtless, in many Cases, be as useful to them, as they are to many of those at Land.

As to the Proposal at the end of this Book, to cleanse some Rivers and Harbours of Mud ; it first occurred to me many Years since, on seeing the slow and expensive Method, of cleansing the *Yarmouth* River near *Yarmouth*, by means of a large Wheel fix'd to a Barge, and turned by Horses. The Wheel in turning round, takes up Mud in large Buckets, which are fixed to it, and discharge

it into another Barge. A Method which they are under a necessity of using in *Holland*, where the Waters move with a very slow progressive motion: But in Waters which have a greater velocity, I am persuaded that it would be a much more effectual, and expeditious, and consequently a cheaper and better way, to cleanse away Mud, by much stirring of it thus with Horse-Rakes.

I shall be very glad if what I have here offered, shall prove of any service to the Publick, and be consequently acceptable to Your Lordships.

Being with all due Respect,

MY LORDS,

Your Lordships

Obedient humble Servant,

STEPHEN HALES.

T H E P R E F A C E.

I Did not intend any other Preface to this Treatise, than what is contained in the foregoing Dedictory Epistle : But being furnished, while the first part of this Book was printing, by the Favor of Sir Hans Sloane, Bart. out of his Valuable Library, with several Treatises on the Subject ; I shall from them give an Account of what has been formerly attempted for making Sea-Water drinkable, especially what was done by Mr. Walcot and Mr. Fitz-gerald in King Charles the Second's Time.

St. Basil, in his Homilies, says that when Men were cast on an
Island,

Island, where there was no fresh Water, they boiled Sea-Water; and caught the Vapour with Sponges, which they squeezed into another Boiler; and having passed thus, four or five Times from Boilers thro' Sponges, it became drinkable. This tedious way was used before the method of Distilling was known, which was an Invention of the Arabs.

Johannes a Gadesden sive Johannes Anglicus, Anno 1516, says that Sea-Water may be sweetened four ways, viz. by filtrating thro' Sand: By clean Linnen laid over a Boiler, and squeeing the Moisture out, as from the Sponges: By Distillation: As also by thin Bowls made of white Virgin Wax, which 'tis said will free the Water from its Saltness, and from some part of its nauseous Bitter. But this is only a matter of curiosity, because

cause but a very small Quantity can be thus prepared; and in order to make those waxen Bowls fit for farther Filtration, they must be cleansed from the Salt, by being washed in fresh Water.

About the Year 1675, William Walcot, Brother to Sir Thomas Walcot, obtained a Patent for making Sea-Water fresh: And the King, before the Grant of this Patent, had the curiosity to go and see Mr. Walcot do it, which was by distilling it in a very large Still; into the Still he put some Ingredient, which was to cure the distilled Water of any noxious Quality: But what it was, he kept a great secret. I suspect that the principal thing was only Distillation, because in all his printed Accounts of it, he purposely avoids the calling it a Still, but calls it a Machine or Engine,

gine, and Distilling he calls the working of the Machine, not Distilling.

The Reverend Dr. Colbatch, Casuistical Professor at Cambridge, who some Years since desired me to attempt, to make Sea-Water wholesome, informs me that he had good Reason to believe that the Ingredient which Mr. Walcot put into Sea-Water, in order to make it wholesome, was some Preparation of Antimony by Fire.

*In the Year 1683 Mr. Fitz-gerald, Son of the Earl of Kildare, and a near Relation of the Famous Robert Boyle Esq; having upon Mr. Boyle's encouragement made a Discovery of a new easy and practicable way of making salt Water fresh, obtained of the King the Grant of a Patent to himself, Theophilus Oglethorpe, William Bridgman, Thomas Maule, and Patrick Trant Esq's; Lord Faulkland
being*

being afterwards brought in a Partner.

In the Year 1684 Mr. Walcot had Letters Patent granted him by the States General, to make Sea-Water fresh, and putride Water wholesome : Which Mr. Fitz-gerald endeavoured to obtain there also.

After several Tryals at Law between the Patentees Mr. Walcot's Patent was superseded and laid aside ; against which Mr. Walcot brought a Bill in Parliament in the Year 1694, which passed the Commons, but not the House of Lords.

Mr. Walcot asserted before the House of Commons, that Mr. Fitzgerald's Water was rough, harsh, fiery, corroding and tormenting the Body when constantly drank of. This I suspect was the true Reason why both their Methods of preparing fresh Sea-Water

Water were disused, viz. because when they had been used for a considerable time, they were found to disagree with those who drank them.

Mr. Walcot says of his *Water*, that it was smooth, soft, cooling, and would not decay or putrify in many Years, no not in seven Years, when kept at Constantinople. But by its continuing so long in an unputrified State, I suspect there was Spirit of Salt in it, that came over in Distillation: For tho' distilled common *Water* is known to keep longer without putrifying, than undistilled *Water* by reason of its greater purity; yet I found some of the good distilled Sea-*Water* to putrify in some time after Distillation, but that which had in it Spirit of Salt never putrified. A Gudgeon died the fifth Day after it was put into a Pint of good distilled Sea-*Water*,
which

which after standing five Months in a Glass Vessel, was again become so putrid as to be disagreeable to the Taste ; whereas another Gudgeon put into a like quantity of good distilled Sea-Water, lived many Days longer, the Water being very fresh and sweet, it having been distilled but three Days before. I find that a small Degree of Putrefaction in Water, kills Fish ; but if, in order to prevent that Putrefaction, a few Drops of Spirit or Oil of Vitriol be dropped into the Water, then the Fish will live many Days in that Water.

The Patentees deposited the Receipts of the Cements, and other metalline Compositions which they used, sealed up in a silver Box, in the Lord Mayor of London's hands.

Mr. Boyle certified that the few Ingredients made use of by Mr. Fitzgerald

gerald, are fixed in the Fire, and give no noxious Quality to the Water.

Sir Hans Sloane, who saw the Cement which was used in Mr. Fitzgerald's Method, tells me that it looked like common Brick Clay. But whatever it was, there was so small a quantity of it used; that what was sufficient for producing Sixty Tuns of good Water, might be contained in two Bushels.

But since, as is shown in the following Treatise on Sea-Water, two Ounces of Sal Tartar, when distilled with only a Pint of Sea-Water, were not sufficient to detain the noxious parts of that Water from rising, therefore 4320 Pounds weight of it, would not be enough to procure Sixty Tuns of good distilled Sea-Water: And since Salt of Tartar is the strongest Imbiber of sulphureous Substances, and
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the most effectual Preventer of the ill Effects of Spirit of Salt that is hitherto known ; it seems therefore very improbable, that so small a Portion of a clayey Substance should be more effectual for that purpose : which makes me very much suspect, that these Cements, as they were called, were only made use of as a Pretext.

Were I to aim at a Patent for making distilled Sea-Water wholesome, and in order to it would conceal the real easy Method of doing it, viz. by first causing it to putrify and then grow sweet again ; I might here have a fair opportunity of doing it, by putting in any Compound Mixture, which in order to have its good Effect it might be pretended, that it must be thoroughly digested in the Sea-Water ; whereby a sufficient time might

be plausibly gained for its Putrefaction, &c.

Mr. Fitz-gerald's Method met with such great applause, that a Poem was published to celebrate his Praise, and silver Medals were made, representing and illustrating the Art of this new Inventor.

One Jacob Kuffler assisted him ; who, the King said, had not the Art.

A Still of his was set up at Hull and Sheerness : and by Order of the Council in the Year 1692, two of them were to be set up in the Islands of Jersey and Guernsey ; but with no good Effect : The distilled Water was fiery, harsh and corroding.

And in a little Time the Persons concerned with Mr. Fitz-gerald, finding themselves extremely disappointed in their expectation, withdrew from any Partnership with him : Inso-
much

much that his Instruments, which were dear enough before their Effect was known, were soon after sold for old Goods, for want of a vent for them at Sea.

Upon the whole, it seems probable to me, that these Patentees might sometimes have wholesome distilled Sea-Water, viz. when they either kept the first part of any Distillation of Sea-Water for a considerable Time after; or if they Distilled some Sea-Water which had putrified: and this they might probably do, since'tis likely that they were provided with good store of Sea-Water for their Experiments. Now I have shown in the following Treatise, that in both these Cases, good Water may be obtained from Sea-Water taken up near the Nore.

And 'tis probable that Mr. Boyle might happen to try, with a Solution of Silver, some such good Water of Mr. Fitz-gerald's preparing, who might likely bring him the best Water he had. For it is not to be suspected that so worthy and good a Man as Mr. Boyle was, would impose a Falshood on the World, for the sake of any one whatsoever.

*The Solution of Silver in Aquafortis was at that time kept a great Secret, as to its Property of discovering the least quantity of Salt or Spirit of Salt in Water. Had either Mr. Walcot or Mr. Fitz-gerald had the free use of it, and known how to have used it, they might then probably have made a greater progress in what they were in pursuit of; but for want of it, they could not well distinguish, when the Distilled Water was free
from*

from Spirit of Salt, and when not, and therefore, failed in their Attempt.

It was from the use of this Solution of Silver ; and the happy Incident of being furnished with a quantity of Mediterranean Water, by Thomas Tower Esq; Member of Parliament for Wallingford in Berkshire, that I got the insight into this Matter ; which I have given an Account of in the Treatise on Sea-Water.

The great and only Difficulty that now remains in this Affair, is to contrive how to distil great quantities of Water on ship-board ; and that with safety to the Ship from Fire.

It may therefore be of use to give here some Account, of what was done on ship-board, in pursuance of the then current Opinion that Mr. Walcot, or Mr. Fitz-gerald, or both of em had made the happy discovery.

They say that they placed the Still in the Forecastle before the Mast, in a very commodious manner, so that it took up little Room, and was out of Danger.

And a chief Master-Builder of the King's Yard at Deptford certified the Lords Commissioners of the Admiralty, that Mr. Walcot had taken great Pains, and made many Contrivances, and good Provision for safety, and conveniency of Distilling in Ships; having brought the manner of placing his Furnaces to great Perfection; assuring their Lordships, that he would undertake to set them up in the same manner in any of his Majesty's Ships.

In the Year 1683, a Master of a Ship from Barbados certified, that in that Voyage they could distil not only in fair Weather, but also in foul Weather.

They

They say that ninety Gallons may be distilled in 24 Hours, from a Still that is three Feet in Diameter, with less than three Pecks of Coals, and proportionably with any other Fewel. And that the whole Room that will be taken up in the Fewel, and in the few Casks to be employed in the preparing this Water, will be less than the tenth part of Stowage, now employed for Water only. That the Ingredients for 100 Gallons of this Water will not amount to above Twelve-Pence : And that the whole, viz. Fewel and Ingredients, will come to about a Farthing a Gallon.

Another makes the following Computation, viz. In a Voyage to Suratte, there is ordinarily allowed a Butt or 126 Gallons of fresh Water to a Man ; something more than a Bushel of Coals will distil this in a

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Day

Day and a half, or 110 Bushels for 100 Butts. So that if one Butt contain fifteen Bushels, 105 Bushels will lie in the Room of seven Butts; by which means thirteen in fourteen parts may be saved in Stowage, except some few Casks for receiving the Distilled Water; which will also save a great Charge of Butts.

The Prices of the Patentees, were as follows, viz.

The Still cost eighteen Pounds, which will distil about 90 Gallons in twenty four Hours.

They are to buy as much of the Ingredients, for this Operation, as will keep the Still going six Months or more, at the rate of one Shilling value to each 90 Gallons.

And shall be obliged to use the Ingredients, lest the Water be prejudicial to the Health of the Sailors, and
con-

consequently bring a disrepute on the Invention.

Three-Pence the Tun to be paid Yearly by such Ships as use the Still.

They propose hereby to save nine Parts in ten of the Stowage for Water.

But these several Estimates are set too high; they are founded on a supposal, that all the Water thro' the whole Voyages of Ships, is to be distilled; which will hardly ever be.

I find upon inquiry, that it is usual for the East-India Ships, to have Copper Still-Heads fitted to their Kitchen-Boilers, with Worm-Tubs proper for Distillation. But it seems the Ships-Boilers are not tinned within side, and yet they find no Inconvenience in constantly boiling their Meat in them: whence there is some Hopes, that provided they are kept clean

clean from the green Rust, which is very apt to be caused by salt Water, they may then also be used in Distillation. But if any Inconvenience shall be found to arise by Distilling in untinned Copper-Boilers, that Inconvenience would be prevented in a great measure, by tinning them; this at least while the tinning lasted; which in much using will wear off, and must then be new tinned.

Mr. Walcot finding that Copper Vessels gave an ill Quality of Vomiting to the Distilled Water, made use of small Iron Boilers, which if they could be had of a size large enough, would be very proper for the Purpose.

*But whatever Vessels are used in Distillation, great Care must be taken that they are made as clean as possible; since it is fully proved in the following Treatise, the more impure
the*

the Water is which is to be distilled, the Taste of the distilled Water will be proportionably the more disagreeable.

The Common Boilers in Ships, are of Copper, not round, but flat-sided like a Box ; and are called double Kettles, being divided by a Partition into two ; the larger of which has a round Mouth, the lesser an Oval one : To the round one, the Copper Still-Head is fix'd, to the Crown of which is soldered a large Pewter-Pipe called the Swan Neck, on account of its crooked Shape, and to this the Worm-Tub is fixed for Distillation.

These Boilers are of several sizes, containing from 15 to 60 Gallons, in proportion to the different smallness or largeness of the Ships. The largest in East-India Ships contain about 80 Gallons, and in First-Rate Men

Men of War they are much more capacious.

Since good and wholesome fresh Water can now be obtained from Sea-Water, it greatly behoves Seafaring Persons, to contrive and find out the best and most commodious Methods of Distilling it.

To conclude, As the Water which is procured from Sea-Water, in the Method I am going to give an Account of, seems to be in every respect as good, as that which is distilled from common Water, so it is reasonable to conclude that it is as wholesome. And that common distilled Water is wholesome, there is good reason to think, from the Experience of many. Mr. Boyle says, that the great Duke of Tuscany, who much consulted his Health, constantly drank Distilled Water : And they are said

in Italy to drink it as a Delicacy. A Physician at Brest drank it constantly, and enjoyed fine Health.

This good Distilled Sea-Water will therefore not only be of use in the Days of Distress, but there may be this further Benefit from it, viz. that it being thereby made very pure, it will not be so apt to stink as other Water; and may therefore be of use when the Ship's Store of Water stinks and is very disagreeable; for the longer good Distilled Sea-Water is kept, the better tasted it is, it being thereby freed from Empyreum.

T H E
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A N
A C C O U N T
O F

Some ATTEMPTS, to make
Distilled Sea-Water whol-
some.

I.

T is well known that seafaring People, especially in long Voyages, frequently suffer great inconveniences, when their Provision of fresh Water, either falls short or fails them; either by long Calms, contrary Winds, Storms which disable the Rigging of their Ships, or other unforeseen Accidents; which obliges them to come often to a very short Allowance; and sometimes to lose the Benefit of their Voyage, by changing their Course to get at fresh Water: Or if they happen to be provided with a *Still*, then, by drinking unwholesome Distilled Sea-Water, their Healths are greatly endangered, by the most obstinate and incureable Obstructions, Scirrhus Tumors, Cachexies, &c. as

I have been assured, by those who have known by experience, the ill effects of it.

There have both in *England*, *Germany*, *France*, and *Holland*, been several Attempts made, to make Sea-Water more wholesome. I am informed that the *Lapis Mexicanus*, or a soft filtrating Stone in the shape of a large Mortar or boiling Copper, is very much in use among the *Hollanders*; but will not answer the end. It clears the Water from Mud, but will not quite clear it from the salt and bitter Taste. And Mr. *Boyle Godfrey the Chymist* says, in his *Miscellaneous Experiments and Observations*, that Sea-Water being filtrated through Stone Cisterns, the first Pint that runs through will be like pure Water, having no Taste of the Salt, but the next Pint will be as salt as usual. The *Comte de Marfilli* in his *Histoire Physique de la Mere* says, he filtrated Sea-Water, through fifteen earthen Pots, placed over each other; which were filled and tried first with Garden Earth, and then with Sand; but it had very little effect, tho' the sum of the Depth of all the Pots was sixty five Inches; the Sand did best. It has also been attempted by several ways of Distillation, as also by Precipitation, both with and without Distillation, which was attempted

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with

with Alkaline Powders, as Coral, Crabs-Eyes, &c. with Salt and Oil of Tartar; and also with acid vegetables and mineral Substances; but all hitherto to no purpose. Yet this should not discourage us from further Attempts, especially in a Case of so great Concern, to the welfare of so numerous, so considerable and important a part of Mankind as those are *who occupy their Business in great Waters*: And whose numbers as they have within little more than a Century, greatly increased, by a more enlarged Commerce through the World; so are they like to increase more and more in future Generations; and That especially on the vast *Atlantick Ocean*, in proportion as the *European Colonies in America*, may more and more increase in number of Inhabitants.

But notwithstanding there have been many Instances of Peoples preserving their Lives in times of Distress, by the use of very unwholesome Sea-Water; yet I find the mention of any Endeavour, to make it more wholesome, spoke of with Scorn and Contempt by some, as a useless Attempt. Some who belong to large Ships with numerous Crews on board them, are apt to say, where can we have or store sufficient Fewel, to Distill, for the support of such Numbers. Yet we find, that

in Queen Elizabeth's time, Sir Richard Hawkins, who then commanded a Fleet in the *Indies*, did, when Water had failed them, for many Days, even in the Admiral's Ship, procure by Distillation a sufficient quantity of fresh Water to sustain the People. See Dr. Shaw's *Abridgment of Mr. Boyle's Works*, Vol. III. p. 220.

And a Person told me, that on board an *East-India* Ship, in which he was ; for want of fresh Water, the Ship's Crew was sustained fourteen Days, with distilled Sea-Water, which they distilled off at the rate of ten Gallons in a Day. The Instances of being brought to a very short Allowance of Water, are, as I find upon Inquiry, very frequent : I am informed also that many perish at Sea for want of fresh Water to drink.

An experienced Distiller informs me, that with a *Still* that holds thirty Gallons, Water will distill at the rate of fifteen Gallons in seven Hours, which will take up half a Bushel of *Newcastle* Coals ; but in a larger *Still* more will be distilled in equal times, with less Fuel, in proportion to the quantity distilled. Therefore thirty-six Bushels or a Chaldron of Coals will distill 1080 Gallons, Wine Measure, that is, above four Tuns ; or near three
Tuns

Tuns Beer Measure. And as a Chaldron of Coals, weighs about a Tun and half, and a Tun of Water, *Winchester* Measure 2816 Pounds; hence it appears that Coals will distill about three times their quantity or weight of Water. And if fifteen Gallons can be distilled in seven hours, then fifty-one Gallons may be distilled in twenty-four hours, a quantity sufficient for a great number of Men; which might also be much increased, by beginning the Distillation some days before fresh Water is wanted.

And as a Scarcity of Water, can in most cases be foreseen, for some time before; so the Distillation of Sea-Water may be begun some time before it is wanted; suppose but a Week before, then in that time, a great quantity might be provided by Distillation. Suppose but ten Gallons were distilled in a Day and Night, as in the case of the *East-India* Ship above mentioned, that would come to seventy Gallons in a Week: And suppose it be fourteen Days more before there be an opportunity to provide fresh Water at Land; then by keeping the *Still* going there will be two hundred and ten Gallons distilled in those three Weeks. A Provision of fresh Water, which will be sufficient to supply a consider-

able number of Men, for that Time. And where the Ships are larger, and the Crews more numerous, a proportionably larger Provision may be made for a sufficient quantity of distilled Water for their use. But as the much greater part of Merchants Ships, have not many Men on board them, so it will be the more easy to find means to supply them with distilled Sea-Water, in cases of Distress.

I have made these Estimates, of the quantities of Water that may be distilled, only as a Foundation for those concerned in Shipping and long Voyages, to make their Estimates from: For as the Circumstances of the different Sizes of Ships, and number of Men, and different kinds of loading, and different lengths and natures of Voyages, are very various, so those concerned can best judge, what provision of Fuel, and what size of *Stills* and Worm-Tubs will be requisite.

If the Kitchen Boiler, when not used for Cookery, can be made use of for a *Still*, it would be very commodious, as not requiring a separate Fire-place, and *Still*. This I have seen put in practice in private Families: by having a separate Cover which fitted the Boiler well, with a close Joining; In the midst of which Cover, was a Hole of a due proportion

tion to the size of the Boiler ; to which Hole the Pewter-head of the *Still* was aptly fitted ; and the Joinings closed with a stiff Paste made of Bean or Wheat-flower, with Whiting or Chalk wetted with salt Water. And these Ship Boilers being made narrower above than at their middle, a *Still* Head may the more easily be adapted to them. And there being two Boilers in the Kitchens of several Ships ; for greater dispatch, they might either use them both in distilling at the same time, or might, if need require, provide hot Water in one, while not used in Cookery, wherewith to fill the distilling Pot when wanted ; which would much forward the Work. If there be room but for a small Worm-Tub, the Water in it may be changed the oftner, as it grows warm ; it being easy to pump it out, and to pour in cold Water. As to Mr. *Hauton's* contrivance to save the having a Worm-Tub, by causing the distilled Water to pass by a leaden Pipe through the side of the Ship into the Sea, and then being cooled, to return into the Ship ; this Method seems liable to too many Objections to be put in practice. See *Lowthorp's Abridgment of the Philosophical Transactions. Vol. II. p. 297.*

If a *Still* is purposely bought for this use,

I believe it would be most adviseable to have the Pot or Boiler of Cast Iron, but especially the Head of Pewter: because I suspect that when Salt-Water is boiling in a Copper Vessel, the heat may make the Salt more corrosive, and thereby more apt to produce, and bring off *Verdigreece* from the Copper; which would make the distilled Water apt to cause nauseating of Food, and sometimes Vomiting; which as I have been informed, has happened to the Inhabitants of *Antegoa*; where being in great distress for fresh Water, of which they have none but Rain-Water, they had drank for some time distilled Sea-Water; which obliged them to disuse their *Stills*. I hope the following Method of preparing distilled Sea-Water, will be of use to them in long Droughts, when Rain-Water fails them.

For the same Reason also it is adviseable to have the *Still* Head of Pewter, and not of Copper, which may probably contract a green Rust, in laying long by, in the salt Air at Sea. This is what a Person told me, had happened to him at Sea; the Water which was boiled in his Tea-Kettle, causing him and several others who drank of it to vomit; which was occasioned by a green Rust in the Neck of the Kettle: And I have heard of several other
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the like Instances. In answer to this, it may be said, that Salt Meat is frequently boiled in Copper Vessels, without any such ill effects. But then, the Salt is somewhat sheathed in the unctuous Fat of the Meat, whereby its corrosive Acrimony is much rebated. I mention the providing Iron and Pewter *Stills*, rather than those made of Copper, only by way of precaution, being not certain whether those of Copper will have any ill effect, provided they are made very clean. For it is found by Experience, that if Sea-Water stand any time in a Copper Vessel, it will much sooner cause a greater Rust than Rain-Water will.

I am informed, that Wood Fewel is chiefly used in Ships, which in many Ports abroad, costs nothing but the labour of cutting and fetching. A greater bulk of this will be wanting to distill any quantity of Water, than there will of Coal to distill the like quantity. Coals might well be laid in Ballast, in a little compass, but when Ships are full freighted they have little or no Ballast, which is then not to be come at.

But might it not be adviseable in some kinds of Voyages, by way of precaution, to have a Tun, or other quantity of Coals, in some proper place, when it would take up but little
useful

useful Room, especially since so many Tuns of Water may be distilled with one Tun of Coals.

I found by filling a Cask with Coals strike Measure, which held twenty-seven *Winchester* Gallons of Water, that though the Coals are about one fourth part specifically heavier than Water, yet the Water weighed one eleventh part heavier than the Coals.

I have been told, that where there has been occasion to keep a Fire for many Days and Nights continuance, on shipboard, for distilling of Water, they have by way of precaution from danger of Fire, laid a quantity of Salt on the Planks about the Fire-place.

Here will be no danger of firing the Ship, if the *Still* Head should fly off, because Water will not flame, as distilled Spirits will do.

II.

THE particular occasion of my engaging in this Attempt to make distilled Sea-Water wholesome, was from a Conversation I had with some seafaring Persons, who were giving an account of the very bad stinking Water, they were obliged often to make use of at Sea, and of the great hardships they sometimes underwent for want of enough of that bad Water. Whence it occurred to me, that probably

bably distilled Sea-Water might be made more wholesome by *Clarification*, concluding that it abounded with a nauseous bitter *Bitumen*, as I remembred some Authors had said it did : And being fully possessed with an opinion that it was so, I resolved to make the trial, being provided with a Hogshead of Sea-Water, which was taken up near the *Buoy* at the *Nore*, at the mouth of the *Thames*, by the favour and procurement of the *Right Hon. the Lord Vere Beauclerc*, one of the *Lords of the Admiralty*.

I distilled several Gallons of it in large Glass *Retorts*, pouring what came over into the Receiver, from time to time, into separate Glass Vessels ; beginning the first pouring off, when it first began to boil, that I might the better know, whether it grew worse and worse, the farther the Distillation was carried on, which was sometimes done till the Salt in the Water became dry.

I found, the little which was distilled off with a more gentle heat, *viz.* till it began to boil, was pretty well tasted ; but the seven next separate Portions of distilled Water, had a flat, unsalt, nauseous, dry, adust Taste ; and the last and ninth Portion, was more harsh and disagreeable, it tasting more of a kind of Spirit

Spirit of Salt ; for what came over till all was distilled to a dry Salt, was in this ninth Portion : But did not find any Taste like Bitterness or Bitumen. And *Comte Marsilli* observed the same, *viz.* that the bitter bituminous Taste of distilled Mediterranean Sea-Water, was scarcely discernible, when taken up from the Sea, within four or five Inches of its Surface ; but if taken up at greater Depths, for the deeper the more bituminous ; then he says, there is a bitter Taste, which it is difficult to free it from : For after most exact and repeated Distillations, the Water, tho' freed from its Salt, yet retained a kind of viscous glewy Matter ; which is to be perceived sticking to the sides of the Bottles, when the Water is shaken, and which slowly precipitates to the bottom, when the Water is not shaken, which is not found in distilled Fountain Water. But tho' I could not perceive any thing bituminous in this distilled *Nore* Water, yet however, I clarified several Portions of it, with different Degrees of Clarification, both with Whites of Eggs and Isinglass, but all to no purpose ; it was indeed of a more mild, and less nauseous Taste : But that, I found, was owing to the soft mucilaginous quality of the Substances, with which I clarified ; which only covered the

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the nauseous noxious quality of the Water, but did not free the Water from it.

But having once begun, I resolved to make farther Enquiry, by what probable means I could at first think of, or should during the process, get any hint of, from such Experiment as should be made. For it is by making variety of Experiments, and the light which we get, by comparing the Events of them together, that we get hints for farther and farther researches : Following thereby as near as we can, the *Clue* by which Nature leads us, into her more secret recesses. And tho' this Treatise is principally intended for the use of seafaring Persons, yet I hope, those of them, who are not used to Philosophical Researches and Reasonings, will excuse me, while I first give a short account of some previous Experiments, which tho' they do not directly describe the best Method of preparing good distilled Sea-Water ; yet may be of service, to explain the nature, and noxious quality of common distilled Sea-Water.

Having therefore Reason to suspect, from the Taste of this distilled Water ; but especially from the last Portion of the Distillation, that there was a Spirit of Salt raised by the heat of the Fire, and mixed with the distilled Water ;

Water ; I dissolved some Silver in double *Aquafortis*, according to Mr. Boyle's Direction, Vol. I. p. 54. of Dr. Shaw's *Abridgment*, and dropped sixty Drops of this Solution into an Ounce of pure distilled Spring-Water. Then putting about half a spoonful of the several Portions of the distilled Water into different Wine Glasses ; I dropped into each of the Glasses two Drops of the Solution of Silver, diluted in distilled Spring Water ; which immediately caused white Clouds in the clear distilled Sea-Water ; which were least in the first Portion, and nearly the same in all the other Glasses, except the last, which had much whiter and thicker Clouds. Whence it was evident, that there was some Spirit of Salt in all the distilled Water. For as Mr. Boyle observes, if there be any common Salt, or its Spirit, in the Water into which the Solution of Silver is dropped ; that Salt or Spirit immediately seizing on the *Aquafortis*, it lets go the Silver which it had dissolved, which is thereby precipitated to the bottom, in the form of a white *Calx* ; whereby the least quantity of Salt, or of its Spirit, is discovered in any Water ; but it will not discover Nitre, Alum, or Borax.

And that there is some Spirit of Salt in this distilled Sea-Water, is further probable from
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the following Observations, *viz.* That this distilled Water does not putrifie and stink, as common Water does; and even Sea-Water, which will putrifie and stink much tho' it has Salt in it. Now I have found by often repeated Experiments, that three Drops of Oil of Sulphur, which is an acid Spirit, will preserve a Quart of common Water, from putrifying, for many Months: And doubtless Spirit of Salt, which is an acid Spirit too, has the same effect. *Fioravanti*, l. 1. *Physices*, c. 95. mentions as a great Secret, that a little distilled Sea-Water, mixed with common Water, will preserve it long from Putrefaction. *Du Hamel Regiæ Scientiarum Academiæ Historia*. And it is probable this, or Oil of Sulphur, or Spirit of Vitriol, was the Mixture with fresh Water, to preserve it from Putrefaction, which the *French* were said, not long since in the News-Papers, to send to Sea.

The following Experiment, is a further Confirmation, that there is Spirit of Salt in distilled Sea-Water; *viz.* I put into two Ounces of the last Portion, of the Distillation to Dryness, of Sea-water; a small piece of fresh Beef: And put Beef also into the like quantities of well-cured, distilled Sea-Water, and also of Rain-

Rain-Water. In seven days, the two last were become very foetid and putrid; and the Waters thick and cloudy; whereas the Beef in the very bad distilled Sea-Water, did not putrifie, nor was the Water turbid, but clear as at first, though kept seven or eight Weeks with the Flesh in it: And it was observable, that the restraining Quality of the bad distilled Sea-water, was so great, that it contracted the Fibres and Blood-Vessels of the Beef, so that no Blood could issue out of it; as it did from the first day, from the Beef in the other Glasses, which had good wholesome distilled Sea-Water, or Rain-Water in them.

Now it is not likely, that an oily bituminous Substance should have this effect in hardening and preserving Flesh; the Effect of such Substances is rather to soften and promote Putrefaction. In order therefore to make some Estimate of the Quantity of Spirit of Salt that was requisite to have this Effect on Flesh; I put some Pieces of fresh Beef into several Portions of common Water, with different Quantities of Spirit of Salt, and found that the Proportion of three Drops to an Ounce of Water, would preserve Flesh from stinking for a considerable time.

The Action of Fire gives those distill'd Salts, what is called a *Polarity*, such as the Filings of Iron have ; for when attracted by a Loadstone, they stand an end, and thereby form rough sharp Points, like little Bristles: And 'tis in some such like manner, that the Particles of Spirit of Salt are to be formed ; whereby they acquire a great degree of Acidity, and a restraining austere Roughness.

From this Experiment, we may plainly see, how common distilled Sea-water works its most pernicious Effects, on those who drink it, *viz.* By contracting and purring up the fine Vessels and Fibres of the Body : whereby it brings on those inveterate and most incurable Obstructions and scirrhus Tumours, which are observed to be the Effect of drinking those unwholesome Waters.

And it is almost in the same manner, tho' by lower Degrees, that *Brandy, Rum, Arrack*, and other distilled spirituous Liquors, do so effectually destroy multitudes of those, who indulge themselves in drinking them. For I have found, by putting raw Flesh, into the several sorts of them, that they all in like manner harden Flesh, by their pernicious burning, caustick Salts, which are more hurtful, tho' of another kind, than those of Spirit of Salt.

And hence it is that *Brandy, Rum, &c.* destroy such Multitudes, especially *in hot Climates*, by adding *Oil* and *Fewel* to the Fire. The Physicians of the sick and wounded Sailors, have assured me, that the Effects of these Liquors on human Bodies, are so pernicious, that their Medicines, have little or no Effect in curing those who have indulged much in *Brandy* or *Rum*.

Thus the *Still*, which makes good Drink, out of unwholsome Sea-Water, procures also from wholsome Wine or Malt-drink, a most pernicious Liquor, which yearly destroys, all over the World, innumerably more, than the three great Plagues of *War, Pestilence, or Famine* ever did. It would therefore be something worse than straining at a *Gnat*, and swallowing a *Camel*, for me to be labouring to cure the ill Effects of common distill'd Sea-Water ; which may be of service to some few, in cases of Distress ; few indeed in comparison of the vast numbers that are destroy'd by distilled spirituous Liquors ; and yet at the same time not to caution against the use of those pestilent Liquors, which may truly be called the *Bane of Mankind*: And which every one, who has any Bowels of Pity for his Fellow-Creatures, should do his best to deter them from.

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But notwithstanding it shortens the Lives of, and destroys vastly more, than *Storms*, *Shipwrecks* and other Accidents, to which Navigators are subject; yet how fond are they of this enchanting *Syren*, which bewitches and infatuates the Nations of the Earth with its Sorceries? Infomuch, that were it put to their choice, whether they would chuse to carry to Sea with them, a *Still* that would draw wholsome Water from the Sea, or one that could extract *Rum* and *Brandy* from Sea-Water; one needs not the Skill of an *Oedipus*, to know which they would prefer.

They pretend that it comforts, warms and defends them, from the severe Colds, to which they are sometimes exposed, without which, they say, they should perish with Cold: which is probably in a great measure true, of those who are much habituated to drink it, the Blood of such, being thereby so much impoverished, that it is well known, that many of the habitual Drinkers of *Brandy*, &c. are cold and lifeless, even in the midst of Summer, without frequent fresh Draughts of it. But on the other hand, how much better able, to endure the Cold and Hard-

ships at Sea, are the sober seafaring Persons, who are generally of a more fine, hail, robust Constitution, than most other Men. Their vital Heat, not being extinguished with Intemperance, does by its kindly genial Warmth, more effectually secure them from the Inclemency of the Weather, than the false momentary Flush of Heat which a Dram gives. Besides, it is well known, that Sailors did not perish with cold, in former Ages, for want of Drams, when they were not to be had.

Dr. Short, in his Rational Discourse of the inward Uses of Water, observes, “ That
 “ it is no rarity, to find among the *High-*
 “ *landers of Scotland*, People of *eighty*,
 “ *ninety*, yea a *hundred* years old, as
 “ healthy, as strong and nimble, as Drinkers
 “ of strong Liquors are at thirty-six, or forty
 “ years of Age.” And this Disparity is doubtless much greater, when apply’d to the Drinkers of enervating Drams.

It may not be improper here, to insert a Panegyrick on Temperance from *Dr. Short’s History of Mineral Waters*, p. 9. A Panegyrick worthy to be recorded in every one’s memory. “ O! Temperance! thou
 “ Support, and Attendant of other Virtues!
 “ thou

“ Thou Preserver and Restorer of Health,
 “ and Protractor of Life ! Thou Maintainer
 “ of the Dignity and Liberty of rational
 “ Beings from the wretched inhuman Slavery
 “ of *Sensuality, Taste, Custom* and *Example* !
 “ Thou Brightner of the Understanding and
 “ Memory ! Thou Sweetner of Life and all
 “ its Comforts ! Thou Companion of Reason,
 “ and Guard of the Passions ! Thou bounti-
 “ ful Rewarder of thy Admirers and Fol-
 “ lowers ! how do thine Excellencies extort
 “ the unwilling Commendations of thine E-
 “ nemies ! and with what rapturous Plea-
 “ sures can thy Friends raise up a Panegy-
 “ rick in thy Praise !”

The Doctor farther observes in his *Ratio-
 nal Discourse of the inward Uses of Water*,
 “ What great Success, Victories, and valiant
 “ Atchievements, a pitiful and despicable
 “ People, have attained over other Nations,
 “ while they were Temperate : but when
 “ they have taken themselves to swill
 “ down strong Liquors, how have they sud-
 “ denly become the Prey, and Contempt
 “ of such as they formerly had trodden down.
 “ — They conquered People and over-ran
 “ Nations, till their Armies began to drink
 “ Strong Liquors, and then they neither could

“conquer nor defend, what they had brought
“under their Yoke.”

I hope this short Digression will be excused, and taken in good part, by those for whose service and welfare it was really intended, by him, who has been labouring to do them the best Service he can, and who has ever had a great value and esteem for *Seafaring* Persons, on account of that *open, brave, generous and manly Spirit*, which is observable in them; and which 'tis a great Pity to have debased and broken down, by such pernicious false Spirits.

How praise-worthy and glorious an Action would it be, for the Legislators and Governors of the Nations of the Earth; to use their best endeavours, to deliver their Subjects from so destructive a Pest, and from that worst of Slaveries, *which it is not in their Subjects power to deliver themselves from*. This would be a surer means to increase the real Strength and Riches of a Nation; and a more glorious Atchievement to gain true solid Honour and Applause, than to inlarge their Dominions by Conquest. On the other hand, how inhuman, how dishonourable, and how gross a breach of Trust committed to them by Providence, is it, supinely to suffer so destructive

a Pest, to rage amongst those committed to their charge; a Pest that so greatly debases human Nature. It is the peculiar happiness of this Nation, that the Legislature have taken Cognizance of it, so as to lay Restraints on, and will doubtless proceed, to provide an effectual Remedy for so great an Evil.

But to return to the Subject of this *Spirit of Salt*; it does not probably rise from the Perfect Salt which is in the Sea-Water, but seems rather to be the Spirit of a more imperfect Salt, which abounds in Sea-Water, and is called *Bittern*. Now the Spirit of this Salt, may probably be raised with a much less degree of Fire, than the Spirit of common Salt: Because, as the Chymists observe, it wants a central Earth, which makes true perfect Salt of so fixt a nature, that its Spirit cannot be raised, without being mixed with powdered Bole or Brick-dust, and distilled in a Retort with a strong melting Fire; whereas the Spirit of imperfect *Bittern* Salt, is more easily raised with a much less degree of Heat, *viz.* that of boiling Water.

Finding therefore so great Reason to conclude, that it was a *Spirit of Salt*, which, principally made distilled Sea-Water so unwholesome; and it being a known thing, in the Books of Chymists, that Oil of *Tartar*,

being mixed with Spirit of Salt, will make true common Salt, as well as strongly imbibe the rancid Sulphur of any Liquor it is put into ; I dropped fixty Drops of strong Oil of *Tartar* into an Ounce of distilled Sea-Water, and distilled it a second time ; it was well tasted, and gave no white Clouds with Solution of Silver. A probable Argument, that the Oil of *Tartar* had seized on and fixed the Spirit of Salt, as perhaps also some of the nauseous Bituminous Sulphur, and thereby hindred them from distilling over into the Receiver. It was also the same, when I distilled half a Pint of distilled Sea-Water, with a quarter of an Ounce of *Tartar*, or with *Sal Tartar*. And with Pot-ash it gave no white Clouds with the Solution of Silver, but it had a very nauseous soapy Taste ; which continued long after.

But two Ounces of *Sal Tartar*, had no sensibly good effect, when distilled with a Pint of Sea-Water ; and it was the same when either Sea-Water, or distilled Sea-Water, were distilled with *decrepitated* Salt, that is Salt burnt in a Pot till it has done snapping.

Half a Pint of distilled Sea-Water, distilled again with half an Ounce of *Calx* of Bones
burnt

burnt to a white Powder, was well tasted, and gave no white Clouds with Solution of Silver. But if it be not thus distill'd a second time, the *Calx* of Bones by standing some Days in the distilled Water, takes off much of its adust Taste, but does not prevent its giving white Clouds with the Solution of Silver; and whereas, had it been distilled a second time, there would have been no such Clouds, this shews that the *Calx* of Bones seizes on the Spirit of Salt and prevents its rising: it was very good three Months after.

Distilling a second time with calcined Oyster Shells, has the same good effect, but tastes somewhat more Adust, but after long standing is good.

Distilling a second time with Chalk, prevents the white Clouds, with Solution of Silver; as also with Brick-dust, which gives a very nauseous Taste.

With Burnt Alum, there are very small whitish Clouds, and it has a smart dryish Taste, but is otherwise well tasted; and continues so long.

These Distillations were made with great ease, in small Pint and Half-Pint Retorts; which

which were placed in common Pipkins filled with Sand; and then placed on a *Trivet* over the Kitchen Fire, for half an Hour, to be gently warmed; and then, the *Trivet* being taken away, the Pipkin was set on a hot place on the Fire. It was easy to fit Receivers of any Sizes to these small Retorts, by means of Corks which filled the Mouths of the Receivers, and had a small Hole in them, fit for the Neck of the Retort to enter.

Thus we see that *Oil* and *Salt of Tartar*, *Calx* of Bones, *Oyster-Shells*, *Chalk* and *Brick-dust*, have a good effect in curing the noxious quality of distilled Sea-Water: But this, not without a second Distillation, which so greatly increases the difficulty of coming at good Water; that nothing but the most urgent necessity, could have prevailed with any to make use of either of these means.

III.

THERE was another Method, which I had thought on, to try as soon as opportunity offered: and that was to see what could be done by Putrefaction. But this, I had as yet no opportunity of trying, because my Hogs-head

head of Sea-Water, having hitherto had its Bung-hole open, did not stink. But I was happily supplied by a Friend with twenty-two Flasks of *Mediterranean* Sea-Water taken up nineteen Months before, thirty Leagues North of the Isle of *Malta*. The greatest part of this Sea-Water was sweet, and in Taste I found no difference between that, and the *Nore* Water.

I cut off the Necks of two *Florence* Flasks to a wide mouth, and then, having weighed them both, I put into one of them, half a Pound *Avoirdupoise* of *Mediterranean* Water; and into the other, the like quantity of *Nore* Water: And then evaporated them both to dryness. I found by weighing them again, that there were two Drams or 120 Grains of Salt in the *Nore* Water, viz. $\frac{1}{29.2}$ part of the Sea-Water: And in the *Mediterranean* Water 128 Grains of Salt, viz. $\frac{1}{27.3}$ part of the Sea-Water, it having one fifteenth part, more of Salt in it.

I distilled in a large Glass Retort, fifteen Flasks of the *Mediterranean* Water, which did not stink: And I observed that during the Distillation, its smell was not so Aduſt and disagreeable, as that of distilling *Nore* Water: The smell of this distilling *Mediterranean*

near Water, being mild and somewhat urinous. Hence it seems probable that by Putrefaction, its *Bittern* Aduſt Salts, are changed in ſome Degree into a kind of *Sal Ammoniack*. For doubtleſs this Sea-Water had putrified in nineteen Months keeping in Flaſks.

I carried this Diſtillation on, till the Salt was dry at the bottom of the Retort ; and pouring it off from time to time as it was diſtilled, into ſeparate Veſſels ; I, to my great Satisfaction found, that the firſt four Parts in five of this diſtilled Water, gave no white Clouds with Solution of Silver ; had very little more of the Aduſt Taſte, than my Pump-Water, Rain-Water, or the very pure *Combe* Spring-Water, with which *Hampton-Court* is ſerved ; all which acquired an Aduſt Taſte by Diſtillation ; and the more impure the Water, the more diſagreeable was the Aduſt Taſte, even after it had putrified and was grown ſweet, which was the Caſe of my Pump-Water, which is hard, and has five Grains of Sediment in a Pound of it, evaporated to dryneſs, whereas *Hampton-Court* and Rain-Water have but one Grain and a half. But if theſe diſtilled freſh Waters, or Sea-Water, ſtand for ſome time, either expoſed to the Air, in open Veſſels, or in

in Bottles, this Aduſt Taſte is much abated ; and at length goes quite off.

It is obſervable, that though diſtilled Rain-Water, Spring or Well-Water, have an Aduſt diſagreeable Taſte, yet the Waters which remain in the Retorts, have only the Taſte of common boiled Water : which ſhows that the Aduſt *Empireumatick* Taſte, is owing to the Action of Fire on the aſcending diſtilled Vapours. The Sun indeed can raiſe Vapours from Water, with a very gentle Warmth, and thereby give no ill Taſte to thoſe Vapours, but this cannot be done by diſtilling.

And as a farther Proof of the goodneſs of this diſtilled *Mediterranean* Water ; I find it putrifies and ſtinks by ſtanding ſome Days, in a Glaſs Veſſel covered only with Paper, not tied down. And when expoſed to the free open Air, ſoon came ſweet again : whereas none of the *Nore* Water has ſtunk, which was diſtilled before it had putrified, and gave white Clouds with a Solution of Silver ; notwithstanding it has ſtood ſeveral Months in Glaſs Veſſels covered with Paper. And raw Beef, as I obſerved before, putrifies and ſtinks in this diſtilled Water, as ſoon as in Rain Water ; whereas the like Beef put into the latter part of this Diſtillation, with which a Spirit

Spirit of Salt was raised, continued hard and did not putrify in standing several Months.

IV.

IN order, further to examine into the goodness of this distilled *Mediterranean Water*; I boiled for two hours, some common yellow boiling Pease, in some of it; also in distilled *Nore Water*, in *Rain Water*, and in undistilled *Nore Water*. The Pease which were boiled in the undistilled Sea-Water, were dusky coloured and very hard; and such are found indigestible, by those who have been obliged to eat them for want of other Food. Those which were boiled in the distilled *Mediterranean Water*, were very soft and mellow to a Mash; those which were boiled in the distilled *Nore Water*, were soft, but not to the same degree as the other. Those boiled in Rain Water were soft too, but in a less degree than the two distilled Waters; which shows that Distillation has more effect in preparing Water to soften Pease boiled in it, than the small quantity of Spirit of Salt, in the distilled *Nore Water* had, to disqualify it for that purpose: But I found that Pease boiled in the last part of a Distillation of Sea-Water to dryness, in which there

is much Spirit of Salt, were far from being so mellow and soft.

I observed, that when the good distilled *Mediterranean* Water had stood some Weeks, if two or three Drops of *Solution of Silver* were dropped into a spoonfull of it; tho' it did not cause White Clouds, yet in standing some Hours, the Water turned brownish, with some sediment; and I found it the same with my distilled Pump-Water: also in Rain-Water when tending towards Putrefaction. So that we cannot hence infer any bad quality in the distilled Sea-Water. I found it the same also in the best of the sweet distilled *Nore* Water, but not in that which was the latter part of the Distillation to dryness, which abounded more with Spirit of Salt.

I observe further on this Distillation, that when about two thirds of the Sea-Water was distilled off, there appeared, about an Inch above the Surface of the distilling Water, a Circle of whitish Salt, sticking to the sides of the Retort, which increased more and more, as the Water decreased by Distillation, yet no Spirit arose from this Salt, till about four Parts in five was distilled off. Hence we may observe, that this Spirit

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rit of Salt, is not so apt to rise in Distillation, from the incruſted Salt, whoſe Water had putrified and grown ſweet, as from the incruſted Salt of Sea-Water that was never putrid.

The way to know, when enough Water is drawn off any one Diſtillation, is, from time to time, to try a little of it in a Glaſs, by dropping two or three Drops of Solution of Silver, as above mentioned.

I purpoſely choſe to make uſe of Glaſs Veſſels, rather than Metalline ones, both that I might the better obſerve what occurred in the Diſtillations, and alſo that I might be ſecure that no ill Taſte was given to the diſtilled Liquors by the Veſſels. In the ſtrongeſt boilings the Ebullition riſes three or four Inches above the Surface of the Water, ſo that care muſt be taken, not to fill the *Stills* ſo full, as to endanger the Water's boiling over into the Neck of the *Still*: And that eſpecially on Ship-board, where there is more danger of the Water's riſing too high, by the heeling to and fro of the Ship; to prevent which, the upper part of the Ship-Boilers are made narrower than the middle parts. I never obſerved any Scum on the Surface of the boiling Sea-Water.

Some

Some of the Flasks of this *Mediterranean* Water, being very putrid and stinking much, I put the Water of none of them into the great Retort, with the fifteen Flasks of Water. But distilled half the Water of one of the most putrid of them in a lesser Retort: The distilled Water of this, stank intolerably; hence the putrid Particles the most volatile, in Distillation: But what remained in the Retort, was the next Day sweet and clear, and had deposited a dirty Sediment. And putrid Sea-Water does the same, as it grows sweet and clear. And common Salt also, as it melts in a moist Air, is observed to deposite much Earth, with an unctuous, sharp, austere Liquor.

The distilled Water gave brownish Clouds with a Solution of Silver while putrid; and when grown sweet again, gave white Clouds, and did not stink again in long keeping, an argument that there was some Spirit of Salt in it. Whence we see how requisite it is to let Sea-Water not only stink, but also become sweet again, in order to procure by Distillation, wholesome Water from it.

Sea-Salt is observed by Chymists, to be made up of an Acid of a peculiar kind, and of a mineral Alkali, the Acid Portion being

so far intangled, and involved in the other, as hardly to be able to exert its proper Virtues, in a concrete Form: But Putrefaction, that most subtile of all Dissolvents, effectually disjoins and separates all the component Parts of putrifying Bodies, except common Salt, which is of so fixt a Nature, as not to yield to Putrefaction: which is the Reason that it is so effectual a preserver of other Bodies, where there is a sufficient quantity of it used. But there being in Sea-Water not only perfect Sea-Salt, but also a more imperfect *Bittern* Salt and Sulphureous *Bittern*, which last Principles promote Putrefaction, and are thereby disjoined; and after the Putrefaction ceases, are formed into new Combinations: The grosser of which precipitate to the Bottom; whereby it falls out, that the Spirit of the *Bittern* Salt, requiring now more heat to raise it, than before Putrefaction; a considerable quantity of the Sea-Water is distilled over, before this Spirit of Salt begins to rise. But when the Distillation is made during the putrid State of the Water, its putrifying Particles being then disunited, the Spirit of Salt more easily rises in Distillation.

I think it therefore a happy event, that some of this *Mediterranean* Water, had putrified and was sweet again ; and that some of it stank ; otherwise if it had all stank, and by distilling it in that putrid State, I had found it no better than *Nore* unputrid Water, I might probably have been thereby so discouraged from any further pursuits, as not to think of distilling some of it, after it was grown sweet again. By such unforeseen Incidents is Providence sometimes pleased, to give Success to our Researches ; and so little Reason have we *to sacrifice to our own Net* ; as if the discovery were owing to our great Sagacity and Penetration.

If we will confess the Truth, we must needs acknowledge our short-sightedness ; *that we see but as through a Glass darkly. And hardly do we guess aright, at things that are upon Earth, and with labour do we find the things that are before us.* *Wisdom ix. 16.* Yet how common is it to see Men led into the prophane absurdities of *Deism*, from a conceited Opinion of their great Skill, in their several Crafts and Professions ? Thus have I known low Artizans, look upon themselves, as compleatly qualified for *Deists*, from a high conceit they had of their Skill in their

Crafts. And the case is but too often the same in other Professions, where, in reality, the very much they are ignorant of, should rather make them humble, than the little they know, exalt them.

It is to be feared, that the Spirit of *Deism*, which is but too prevailing in our unhappy Days, owes its Rise, in a great measure, among other causes, to an over-weaning conceited Opinion Men have, of the great Strength of their Reason and Understanding ; whereby they are led to make themselves, so far the Standard of Infallibility, as even to reject the Counsel of the Alwise and Almighty Being, in the Conduct and Government of his own Creation. For by the Divine *Counsel*, as the Wise-man observes, *The ways of them which lived on Earth were reformed, and Men were taught the things that are pleasing unto thee, and were saved through Wisdom. Wisdom of Solomon ix. 17, 18.* Had they therefore but Humility enough to make a just Estimate of human Abilities, for Humility is a Virtue full of good Sense, that would neither have us under, nor over-value ourselves ; they would then perceive, how great Reason they had to be thankful, for whatever further Assistance, beyond natural Abili-

Abilities, God would vouchsafe to give us, in order the better to conduct ourselves.

It is observable that the Deistical Spirit is plainly seen in many of them, under the Air of great Self-sufficiency ; as if they, by the dint of their superior Understanding, had discovered the Cheat, which held Mankind under the Restraint and Bondage of Revelation. Yet these professed Enemies to Faith, must needs own, if they will but observe it, that in almost every other part of Life, in which our Understandings are employed, we find incessant Occasion, to act on the fidelity and report of others ; for no one Man can himself try all things. If therefore they would give things Spiritual, but an equal treatment, with the common Occurrences of Life, they might then bid fair for a full Enjoyment of the gracious Promises of the Gospel, which they now most senselessly reject with scorn. *Thus professing themselves Wise, they become Fools. Rom. i. 22.*

But to return to the Subject of this distilled *Mediterranean* Water : I found that the fifth Part of it, which was distilled to dryness, turned Syrup of Violets Red ; which Spirit of Salt also does : An Argument, that there is

Spirit of Salt, in this last distilled Sea-Water ; the Acidity of which is also very manifest to the Taste.

But good distilled *Mediterranean* Water does not change the colour of Syrup of Violets ; whence there does not appear to be any prevailing Acid in it.

But neither did the last part but one of the Distillation of this *Mediterranean* Water change the colour of the Syrup of Violets, notwithstanding it gives White Clouds, with Solution of Silver ; which therefore discovers to us smaller degrees of Spirit of Salt, than Syrup of Violets will do. Hence we have a hint to be careful not to distill off any quantity of Sea-Water, too near to the bottom, because it will thereby, the more abound with Spirit of Salt, and be consequently so much the more unwholesome.

And that the quantity of this Spirit of Salt increases more and more, in proportion as the Distillation is carried on farther and farther, I was convinced by the following Observation, *viz.* Jan. 29th I examined a large Distillation of *Nore* Water which had not putrified, which was kept in eight separate Flasks according to the order of its being distilled off, which was done the preceding *October* 13th. It

It had all lost its a dust Empyrume : And about one third of it gave no white Clouds with Solution of Silver, but the other latter parts of this Distillation, gave very manifest Clouds, and tasted somewhat more tart and rough than the other : Now this whole Distillation from first to last, gave white Clouds at first, and for some Weeks after ; when I first perceived that the quality of giving White Clouds sensibly abated. This shows, that there is not much Spirit of Salt raised in the first third Part of a Distillation of unputrified Sea-Water ; and that the little of it there is, is so incorporated in the Water by long standing, that the Solution of Silver has no effect upon it. In like manner as I have frequently found that a small quantity of Oil of Sulphur, or Spirit of Vitriol, would on long standing be incorporated into Chalybeate Waters.

Hence we see that there is much Spirit of Salt in the latter part of this Distillation.

Hence also we may draw this useful Inference, that in cases of distress, if there should be no Water in the Ship that has stank and become sweet again ; we may with safety make use of distilled Sea-Water that is just taken out of the Sea ; provided on-

ly one third Part of it be distilled off; for 'tis probable that the ill effects of distilled Sea-Water have principally arisen, from Men's not being enough aware of the ill Consequences, of carrying the Distillation on too far.

V.

Jan. 29th, I distilled 22 Cubick Inches of the *Nore* Water out of the Hogshead, which was well closed up *December* the second, in order to cause it to putrify. Some time after the Water in the Hogshead had a disagreeable Smell, and then grew sweet, and continued so to this Day. It is remarkable that with so small a degree of Putrefaction, the Water which was distilled over was good, till the Salt which adhered to the Retort had appeared for some time, whence its Spirit arose as usual. There were sixteen Cubick Inches distilled over, which were good, which is full three fourths of the whole.

Both the smell of this during the Distillation, and also its taste were much better than that of unputrified Sea-Water.

December the second I put some *Nore* Water into a Kilderkin and bunged it up close, where after some time, it contracted a putrid

trid Smell, and Taste, and then became sweet again. Some of it being distilled *Jan.* 29th, it gave no White Clouds with Solution of Silver, though above two thirds were distilled off: Hence again we see that this small degree of Putrefaction will suffice, for the producing of good distilled Sea-Water.

But this distilled Sea-Water, was much more nauseous, than that out of the Hoghead, so that some of the impurity came over in distilling, which the Water had contracted from the Kilderkin; which had for many Years past had Beer in it; yet it was wash'd with hot Water. Thus I have constantly found distilled Water the more nauseous, in proportion to the foulness of the Water it was distilled from.

Hence the Empyreumatick taste, does not seem to depend on Fire Particles inherent in the Water, but rather from a new disagreeable Combination of the more impure parts of the Water; whereas were it owing to Fire Particles, that adust Taste should be more nearly the same, whether the Water were pure or impure.

Nov. 28th, I put some Isinglass into some sweet *Nore* Water, in order to make it putrify, which it soon did in some degree, and

and continued to do so more and more till Jan. 29th, when I distilled some of it in that stinking State. It, to my surprize, gave no Clouds with a Solution of Silver; and when sweet, which it soon became, it tasted as well as the good distilled *Mediterranean* Water. Hence we see that, notwithstanding the *Mediterranean* Water which stank when distilled, gave white Clouds, and continued to do so for several Months after it was distilled; yet that this *Nore* Water tho' distilled in a putrid State proves very good; as it does also, when distilled after it is grown sweet again. I cannot guess at any other Reason for the different event of these two putrid Waters, unless it be that the *Mediterranean* Water was in a more highly putrid State, so as to be turbid, whereas the *Nore* Water seemed to be putrid in a less degree, and was pretty clear.

It seems probable, that it will be more requisite, to have Sea-Water putrify and grow sweet again in the warmer Climates, and where it abounds most with Bitumen; because thereby the Bitumen will be rendered less volatile, and be in a great measure precipitated to the Bottom of the Casks, before it
be

be put into the Still, whereby what is distilled will be the purer.

VI.

Comte Marfilli says, this Bitumen is in such plenty in the *Mediterranean* Sea-Water, particularly on the *Thracian* Sea, when calm; and in such abundance on the *East-Indian* Sea, that it is sometimes seen swimming on the Surface of the Water, which he believes to come in a good measure from Coal Mines; some of it may also come from *Petroleum* which is in many Parts of the Earth. He distilled some Mineral Coals, and found that forty Grains of the oily volatile Spirit of Coals, put into a Quart of fresh Water, which was made as salt as Sea-Water, made it as bitter as the surface Sea-Water: and that fifty Grains of that Spirit, put into a quantity of Artificial Salt-Water, made it as bitter as the deep Sea-Water.

He says also, that the Sea-Salt which is made at *Pescais* near the Mouth of the River *Rhone*, is so bitter and disagreeable, that it can't be used the first Year, and scarcely the second; that it is tolerable the third; and the fourth Year its Bitter is scarce to be

be tasted ; and this, whether the Salt be made by Art or the Sun.

That the Taste of the Salt made by the Distillation of the surface Water, is of a biting Saltness, with an almost intense bitterness : But that the Taste of the Salt of distilled deep Water is of a greater degree of Saltness, and a more disagreeable Bitter.

He says that distilled Sea-Water is so disagreeable, that it is impossible to drink it, *viz.* on account of the great quantity of its *Bitumen*, which is more disagreeable than the saline Part. But this is happily cured by Putrefaction.

If Bread is made with Sea-Water, he says it gives a good Colour, and makes it light ; but that the *Bitter* which is tasted the next day, makes it intolerable. And that *Mutton* boiled in *Sea-Water*, is more Salt and Bitter than in *fresh Water*.

He observes, that there is something lost in Distillation ; for though the Salt thereby taken out, be restored to the Water, yet there wants an addition of more Salt, to bring it to its former Specifick Gravity, *viz.* forty Grains in two Pounds.

That there are in two Pounds of Sea-Water, eight Drams and six Grains of Salt ;
and

and in an hundred Pounds, 402 Drams thirty Grains, yet in the Distillation there were found in two Pounds of Sea-Water, but six Drams thirty Grains: And in an hundred Pounds 325 Drams. And it is the same, when common Water is made as salt as Sea-Water and then distilled.

He found also, that two Pounds of Fountain Water will dissolve half a Dram of Salt more than distilled Sea-Water, though their Specifick Gravities are the same; this he thinks is owing to the *Unctuosity* of the distilled Sea-Water.

He laying the Salt of superficial Sea-Water, taken within six Inches of the Surface, and the Salt of deep Sea-Water on blue Paper, the first Salt turned the Paper Red as Nitre will do, but the other Salt had no such effect.

I dipped some Blue Paper in the melted Brine of the Salt, both of the distilled *Mediterranean* and *Nore* Water, and then dried the Papers, which both gave a reddish cast: But a like Paper dipped in a strong Brine of common Household Salt, had not such a reddish Colour, which shows that the Bittern Salt of Sea-Water is partly Nitrous. And since Chymists observe that Nitre consists of
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an *Oily Saline*, and *Volatile* Substance, no wonder that Nitrous Salt should be formed in the *Bittern* Salt and *oily Bitumen* of Sea-Water: And it is supposed to be owing to the great plenty of this Nitrous Salt, that Sea-Water is observed to be more unapt to extinguish Ships on fire, than fresh Water. It was observable that the Papers which were dipped, in the Colliquation of the Residue of the Distillations, melted again much sooner, and in a greater Degree, than the Paper dipped in the Brine of common Salt, *viz.* because of the imperfect bittern Salt which was in them.

This *Bittern Salt*, of which there is great store in the Sea, is thought to enter much into the Composition of the Nourishment of Plants and Animals.

It is from this probably, that that *Universal Salt* arises, which as it happens to fall on different Earths, concretes, and corrodes them, and thereby produces different kinds of Salts; the more common whereof, and such as are found Natural, are *Vitriol*, *Alum*, *Nitre*, *common Salt* and *Sal Ammoniac*.

And 'tis probable that from the sulphureous *Bitumen* of the Sea, is raised by the warmth

warmth of the Sun, that *subtile Sulphur*, with which the Air, and its Waters, *viz.* Dew and Rain are impregnated; which makes them so kindly and congenial for the Nourishment of the Products of the Earth: And when the Air is much impregnated with these sulphureous Vapours; they cause violent Ferments with purer Air, whence *the Explosions of Lightening*; as I have shown in my *Analysis* of the Air.

VII.

I conclude there will be little or no difficulty in being provided with Sea-Water that has putrified and grown sweet again; since as soon as any Fresh-Water Cask is emptied, it may be filled with Sea-Water; which I am told is the constant Practice in many Ships, in order to preserve a due Proportion of Ballast, &c. And when the Cask is close bunged down, this will promote Putrefaction; as will also the Filth and Sediment, of what remained of the fresh Water. But the Putrefaction may be hastened, by throwing in a few Scraps of any animal Substance, whether it be of Fish or other Animals. This I found, that *Isinglass*, which is a fishy Substance, soon caused it to putrify. And in
warm

warm Climates where the Sea-Water abounds most with *Bitumen*, it will, both on account of the greater quantity of *Bitumen*, as well as of warmth, be the more disposed to putrify.

When the Sea-Water is well putrified, it will be convenient to use means to make it grow sweet again, *viz.* by opening the Bung-Holes, as also by throwing in a little clean Sand, which will help to fine down the Water, by precipitating its turbid Filth. But I have not found Sand to hasten the sweetening of stinking Sea-Water that was clear; but when turbid and thick, the Sand will then have a good effect, in carrying all foulness down with it; as it is well known to do when mixed with slimy Isinglass in fining of Wines.

As new distilled Sea-Water, though freed both from Spirit of Salt and *Bitumen*, has but an indifferent flat adust Taste; this may in some degree be helped, by exposing it as much as the Time will permit, to the Air, and pouring it often to and fro : Mr. Boyle Godfrey, in his *Miscellaneous Experiments and Observations*, advises the putting in a few Grains of Salt, or a little Sugar,

to

to give it a Taste. Powder of well-burnt Bones will much take off the adust Taste.

Some are of Opinion that distilled Water cannot be wholesome, because they suspect that it is thereby deprived of its nourishing Quality. As new distilled Water is less palatable than the undistilled, so it may not probably be so congenial to our Bodies, on account of that new Texture that is given to some of its Parts; to which its disagreeableness seems principally to be owing, and not to its being deprived of its nutritive Parts. For when I had set by, for a considerable Time, some good distilled *Mediterranean* Water, it became very well tasted, like other common Water, notwithstanding it was all that Time in a well corked Bottle; so that it could not have any fresh *Pabulum* or nourishing Quality communicated to it out of the Air; which was excluded by the Cork of the Bottle. And when distilled *Nore* Water, which had a disagreeable Empyreuma, was distilled over again with Salt or Oil of Tartar thrown into it, which detained the heterogeneous Parts of the Water from rising in Distillation, the distilling Water was then free from Empyreuma, notwithstanding it had undergone the Action of Fire now,

as much as in the first Distillation. Water is to be looked on chiefly as a Vehicle of Nourishment; and if that Vehicle be deprived of its former noxious Qualities by Distillation, we may then reasonably hope, that it may be tolerably good, for conveying Nourishment, the being blended with which may also much amend it, tho' it be not so agreeable to the Taste, nor altogether so congenial to our Bodies as other fresh Water.

VIII.

1st. Upon the whole, we may observe, as far as appears from these Experiments and Observations, that the best Method to procure wholesome Water from the Sea, is first to let it putrify well, and then become sweet before it be distilled, by which means the greatest proportion of good Water may be procured from any one Distillation.

2dly. That as appears by the stinking *Nore* Water, a smaller degree of Putrefaction, and then turning sweet, will suffice to procure about three fourths of good Water from a Distillation, at least in these Northern Seas, where there is a less quantity of Bitumen: Whether this small degree of Putrefaction, will

will be sufficient, in warmer Climates, must be left to Experience to determine.

3dly. *Nore* Water distilled even in a putrid State, yielded good well tasted Water, as soon as it grew sweet, which it soon did after Distillation.

4thly. That Water kept in a Beer-Cask, gives a much more nauseous Taste, when distilled, than from a Water-Cask.

5thly. That when on account of a sudden unforeseen Exigency and Distress, there is not time to have Sea-Water stink, and grow sweet again: Then, if only one third of each Still full of Water be distilled off, but a small quantity of Spirit of Salt will arise: And if they will have the præcaution to be provided with two or three Pounds of Salt of Tartar, kept dry in Bottles, a very little of this will change the acid Spirit of Salt in the Water, into a more wholesome neutral Salt: But then there will remain the very nauseous oily Bitumen; the most effectual way to be secured against which, will be, to be well provided with putrid Water if possible.

6thly. It will be requisite also to be provided with a small Vial full of a Solution of Silver in *Aquafortis*. A small Bit of Silver, viz. no bigger than a Silver Three-Pence,

dissolved in the quantity of a middling spoonfull of *Aquafortis*; and sixty Drops of this dropped in an Ounce of distilled fresh Water, will suffice. But the Water must be distilled, else, there being some degree of Salt in most Waters, the Solution of Silver will cause white Clouds in them, which will make them unfit for the Purpose. The purer the Silver the better. I dissolved a Link of a Watch-Chain, which having Copper in it to make it the stiffer, the Solution was green; yet when sixty Drops of this were dropped on an Ounce, or about three spoonfull of distilled Spring Water, it was clear, and did very well for my purpose. I mention this, to put those, who shall have occasion for it, in an easy way of procuring it, when they have not an opportunity, either to get very pure Silver, or to purchase the Solution of Chymists. Two Drops of this Solution dropped into a Glass with half a spoonful of the distilling Water, will presently discover, by the white Clouds it causes, if there be any Spirit of Salt risen with the Water.

7thly. It will be of use also to observe, when a Distillation is over, in what degree of the Distillation, the dry Salt begins to incrust on the sides of the Still; as also how far

far

far the Distillation may be carried on without danger of raising Spirit of Salt, after this dry Salt first appears. For the *Mediterranean* Sea-Water came over good, a considerable time after the Salt appeared on the sides of the Retort.

Further Experience and Observations from Skilful Persons may hereafter give more light into this matter, which they will do well to communicate, in order to have them made known, for the publick Benefit; towards the promoting of which, I shall be very glad if these Endeavours of mine shall prove of any service: which would give me such a Satisfaction, as would be an ample Reward, for the Labour and Pains, I have taken herein, even tho' they had been much greater.



S O M E
C O N S I D E R A T I O N S

A B O U T

Means to preserve F R E S H
W A T E R sweet.

The *Thames* and several other Waters will stink in seven or eight Days, and sometimes sooner, especially in unseasoned Casks, and come sweet again: By opening the Bung-Hole, Waters often become sweet in twenty four Hours, and sooner, when much shaken, or poured to and fro. The Water would stink more, if the Bung-Holes were not left partly open. But putrid Water, tho' nauseous, is not observed to be hurtful to human Bodies.

Dr. Boerhaave in his Chymistry, Vol. I. p. 598, says that when Rain Water stinks, if it be just boiled, all the living Creatures in it will be killed; and on standing to settle a while, they will subside with other Sediment, to the Bottom: Then being acidulated with some pure acid Spirit, the Water is observed to become most wholesome: And that by the same means, *viz.* by adding a little Spirit of Vitriol, Water may be preserved from putrifying, or breeding Insects, and yet be withal very healthful: But as he has not mentioned what proportion of this acid Spirit should be put in, and as a small Error in excess of the quantity of this very acid Spirit, may render it far from wholesome, even very hurtful and noxious; I will
here

here give an Account of what Experiments and Observations, I have made on this Subject, in endeavouring to preserve the Virtue of Chalybeate Waters.

I have found that three Drops of Oil of Sulphur in a Wine Quart of Water, have preserved the Water from stinking for many Months, and even two Drops to a Quart of very pure Spring Water, which came from a gravelly Hill, which was all Gravel to its Surface, have preserved it sweet for more than six Months: I have observed the Water of such Springs as came from Gravel, to be the purest of any Spring Water, it being filtrated through the finer Sand of that Gravel, which consisting of innumerable small flinty Stones, give no Tincture to the Water, but purify it as it glides through its fine Meanders. Snow and Hail Waters are the purest of any: But Rain Water abounding with Sulphur, especially in hot Weather, is apt to putrify; the purer the Water, so much the lesser quantity of acid Spirit will preserve it.

I have from my own Experience, and that of others, known Steel Waters drank with three Drops of Oil of Sulphur to a Wine Quart, not only with much safety, but with
great

great benefit, when drank only in the quantity of a Quart, or Pint, or Pint and half, in a Morning, for a few Weeks, and for a much longer continuance, in the small quantity of half, or a quarter of a Pint.

But I shall not take upon me to recommend the use of this Proportion of Oil of Sulphur, or Spirit of Vitriol, in the much larger quantity of Water which is daily drank on Ship-board, lest while I am endeavouring to do what Service I can to Seafaring Persons, I should imprudently do them harm. Yet since the Trial may be made with safety, in the lesser quantities of Water above-mentioned; and since it is well known that Physicians frequently prescribe, to the great benefit of their Patients, twenty four Drops of Elixir of Vitriol, to be drank in a Draft of *Spaw* Water, or other Liquor, for some Days continuance; in which twenty four Drops there are no less than eight Drops of Oil of Vitriol, according to the *London Dispensatory*; which supposing the Draft of *Spaw* Water to be half a Pint, is above ten times more acid Spirit, than these three Drops to a Quart: There can therefore be no danger in making the Trial first in small quantities of Water; which may from time to time
be

be encreased, as from Experience shall be judged proper. Neither would I propose to have the greatest part of the Ship's Water-Casks thus acidulated with Oil of Sulphur or Spirit of Vitriol, but only some few of them, to be made use of where the Ship's Water is extremely nauseous, and till some of it can be made more drinkable by exposing it to the Air, &c.

If any one shall therefore care to make the Trial, and without Trials, few useful Improvements are made; they may take their Estimate from hence, without being at the trouble of counting every Drop they put into a large Cask of Water, *viz.* I found that twenty Drops of Oil of Sulphur, which dropped slowly from a Bottle, weighed twelve Grains: Therefore an Ounce *Troy*, or 480 Grains weight of Drops, will be in Number eight hundred: And there being in a Beer Hogshead seventy two Gallons or 288 Quarts, these at three Drops to a Quart, will take up 864 Drops, that is one Ounce, and sixty four Drops, or thirty eight Grains weight.

And as I have, as above-mentioned, found that a Quart of very pure Water was preserved long sweet, with only two Drops of Oil of Sulphur, it will be adviseable to try
that

that lesser quantity too, which may be used with much greater safety, if it will be effectual to prevent the stinking of the Water, which I believe it will do in purer Waters, in a great measure.

I have frequently observed, that when three Drops of Oil of Sulphur have continued in a Quart of Water for some time, that the little acidity it gives, has gone quite off, so as not to be tasted, the acid Spirit being then more intimately incorporated with the Water.

That two or three Drops of true Oil of Sulphur to a Quart, will prevent the breeding of Insects in Water, is probable from the following Experiments and Observations; *viz.* July 5th, four Drops of Oil of Sulphur to a *Winchester* Quart and half a Pint of Rain Water, killed the little Insects in it, in twenty-four Hours; a less quantity will therefore probably prevent their growth, in their minutest Origin, when they are of a much tenderer Constitution. But as the Insects grew stronger, *viz.* August 10th, eight Drops of Oil of Sulphur, to a like quantity of Water, did not kill them in three or four Days. But ten Drops killed them in two
or

or three Hours, in the same quantity of Water.

I have chiefly mentioned Oil of Sulphur, because it is looked upon, as somewhat more kindly to Animal Bodies, than Spirit of Vitriol, tho' the difference between them is but little: But as it is more difficult and costly to make Oil of Sulphur by the *Bell*, than to distill Spirit or Oil of Vitriol, therefore they are, as I am informed, frequently sold, the one for the other.

Mr. *Boyle Godfrey* the *Chymist*, in his *Miscellaneous Experiments and Observations*,
 “ advises the putting in an Ounce of
 “ true Spirit of Vitriol to every forty Gal-
 “ lons of Water, which is at the rate of
 “ three Drops to a Quart; he says true Spi-
 “ rit, because the Spirit of Vitriol usually
 “ to be met with, is only Oil of Vitriol
 “ mixed with Water, which Oil he would
 “ not advise to be used, because it is a more
 “ metallick Acid than the Spirit, which is the
 “ more Phlegmatick, or lighter Part that
 “ comes up first in Distillation: If the Oil
 “ is ever used, a third part of the Weight
 “ of it does, that is one Ounce of it for three
 “ of Spirit. — This Spirit or Oil will be
 “ very proper for Seamen in hot Climates,
 “ by

“ by hindering a too great Perspiration.—
 “ It is supposed there are not many consump-
 “ tive Men in a Ship, for whom Mine-
 “ ral or other Acids are not good. Page
 “ 136, 137.

Agreeably to what Mr. *Godfrey* observes of the different Degrees of Strength of Spirit and Oil of Vitriol; I have found that one Drop of true Oil of Vitriol has preserved a small degree of the tinging Virtue with Galls, of the Steel Water near *Claremont* in *Surrey*; whereas none of the tinging Virtue of that Water was preserved, with three Drops of true Spirit of Vitriol. I observed also that the efficacy, and consequently the acidity of three Drops of true Oil of Sulphur, was nearly equivalent to that of one Drop of Oil of Vitriol, it having almost the same effect on *Claremont Water*. So that three Drops of this Oil of Sulphur were somewhat stronger than three Drops of the Spirit of Vitriol. It is therefore very requisite to observe Mr. *Godfrey's* Rule, *viz.* to put but one third of Oil of Vitriol, since it is comparatively so much stronger. And since Oil of Vitriol is used in making Elixir of Vitriol, which is frequently prescribed, with safety; we may thence reasonably infer, that there is little danger in
 using

using Oil of Vitriol, provided the above mention'd Rule be observed.

I am informed, that the *Dutch* in long Voyages, to prevent the Water from stinking; always put into it, before they set out, a quantity of Spirit of Vitriol.

In the *History of the Academy of Sciences, Ann. 1722*, it is said, that fresh Water has been preserved from putrifying or breeding Insects for six Weeks, by fuming the Cask with burning Brimstone, as is frequently done to preserve Wine and Cyder. And if when a few Gallons of Water are put into the fumed Cask, the Bung be put in, and it be rolled to and fro; this will make the Fumes more effectually incorporate with the Water; as it does by the same means with Wine and Cyder.

DIRECTIONS

To preserve

Ship-Biscuit and Corn

From being

Eaten by Weevels, Meggots,
or Worms.

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D I R E C T I O N S

To preserve

SHIP-BISCUIT and CORN from being
Eaten by Weevels, Meggots, or
Worms.

THERE is another great Inconvenience to which Seafaring Persons are frequently exposed, by having their Provision of Biscuit and Corn much spoiled, by being eaten by Worms, Meggots, or Weevels, especially in long Voyages; which Inconvenience might probably be in a great measure prevented by the following Means, *viz.*

It is well known that the Fumes of burning Brimstone, are most destructive of animal Life ; and will therefore, not only destroy living Animals, but will also prevent the growth of them in Bread or Corn, which is packed up in close Vessels, in which the Air is strongly impregnated with these Fumes ; which it is well known by repeated Experience, have a Power of destroying, or reducing to a fixt unaerial State, the more wholesome vital part of the Air.

Having therefore filled the Casks with Bread or Corn, or any other vegetable Substance which is liable to be worm-eaten; bore six or eight Holes in one head of the Casks, and two Holes in the other Head, more or less, as Experience shall prove to be best, all of them about the size of common Quart Corks.

And that the Corn may not drop thro' these Holes, nor the Bread stop them up; it will be convenient to nail within side of each Head of the Casks, three or four sticks, about an Inch thick, these sticks having a piece of Hair-cloath, or very coarse Sack-cloath, laid on them, will prevent the falling thro' of the Corn; and yet give room for the Fumes of the Burning Brimstone to ascend: And the sticks, without a Hair-cloath, will prevent the Biscuit from immediately covering the Holes.

Having therefore provided a sufficient quantity of pieces of Tow, or Linnen Rags dipped in melted Brimstone: If the Casks are to be fumed on shore, then, having dug a Hole in the Ground about a Yard deep, and eighteen Inches wide; throw into the Hole, more or less, as Experience shall show best, about a quarter of a Pound of the Brimstoned Tow or Rags, set on Fire: Immediately placing over the Hole, the Cask, with that
end

end which hath most Holes in it, undermost, for the Fumes to ascend thro' them, into the Cask ; which yet they would not do, if there were not some Holes in the upper Head of the Cask, to give vent for the Air to ascend thro'.

When you guess the Brimstone is burnt out, and that the Cask is full of Fumes all over ; which it will be, when they have ascended for some time thro' the upper Holes, then drive Corks into the upper Holes, and turning the Cask side-ways on its Bouge, immediately cork up the lower Holes. The tighter the Cask is, the better and the longer it will keep the Fumes in ; and prevent the entrance of fresh Air, which would promote the breeding of Insects.

But if by reason of the too great closeness of the Hole in the Earth, it shall by experience be found, that the great smother of the Fume, extinguishes the burning Brimstone ; then a less deep Hole may be made use of, on which a Cask may be set with both its Heads out ; the Bread or Corn Cask being set on this, at such a height from the burning Brimstone, as to prevent the Bread or Corn, being scorched by it ; for which purpose about a Yard will be high enough : If need require, there may be two or three Holes boarded in the sides of

the headless Under Cask, or some space left at the bottom, in the Earth, to give vent enough to keep the Brimstone burning.

'Tis probable that by this means, Biscuit, Corn, &c. may be long preserved from being worm-eaten. But in case it shall by experience be found needfull to renew this Fumigation, especially in some long Voyages; it may be done with great safety on ship-board in calm Weather. *viz.* by placing a Cask on Deck with its upper Head out; in the bottom of which let there be near a Foot depth of Ballast, pressed hard down, with a kind of hollow Basin in its middle, wherein to lay the burning Brimstone.

Not only Bread and Corn Casks may be thus fumed again, if need require: But also the Bread in the Bread-Room, if infected with Weevels or Worms, may by being thus fumed in Casks, have all the Vermin destroyed, which will conduce much to the preserving of the Bread, by lessening their number, tho' they cannot thus be wholly extirpated: Because the Bread-Room it self cannot well be fumed at Sea, while the Ship is full of People: Tho' it may safely be done, when in Harbour; by burning then some Brimstone in it, on a thick Bed of Ballast; in a shallow open Tub:
which

which would for a long time preserve the Room from being infected with this Vermin.

I am told, that it is by some such means, that all the Rats in Ships are destroyed when in Harbour. But I must again, and again, caution against using any Fumes of burning Brimstone under Deck, while any Persons are there; for they will instantly be suffocated before they are aware of it.

When the Weevels are got into the Malt or Corn in a Grainery, they might easily be destroyed; by putting the Weevely Corn into Casks or Chests, or large Cases made of Boards, which being placed over Holes in the Ground, with burning Brimstone in them, would soon destroy all living Animals in the Corn, and a great deal of Corn may be thus cured of Weevels, &c. in a little time.

The Weevels in a Grainery full of Corn, may also be destroyed in the following manner, *viz.* Let there be many Holes bored in the Boards of the Grainery of such a size, that the Corn cannot fall thro', or else let there be in several parts of the Floor, large Holes cover'd with Laths, on which Hair-cloaths are to be laid, as in Malt-Kilns. And having provided a large quantity of Tow dipped in melted Brimstone; if the Ground-Floor

Floor of the Grainery be of Earth, lay several heaps of this brimstoned Tow, as big as a Man's Head, in the proportion of about four heaps to every twelve Feet square; taking care, not to place them near the Walls. But if the lower Floor be covered with Boards, then lay the parcels of Brimstone on heaps of Sand or Earth, eight or twelve Inches thick, and laid on Tiles or Bricks, and hard prest down, to prevent the melted Brimstone's getting thro' it : And for greater security, I used to put the Earth into common Wash-Tubs. If the Floor on which the Corn lays, be six Feet distant above the burning Brimstone, there will be no danger of its catching Fire : Yet for fear of mischief, great care must be taken. All Doors and Windows must be closed as much as possible. If there are several Graineries over one another, the Fumes, will pass thro' all with great velocity and acrimony.

The Fumes of burning Brimstone placed thus under the Corn, will ascend through it, with great velocity and acrimony : But if the burning Brimstone is placed above the Corn, tho' confined in a close Place, the Fumes will not then descend into the Corn, as I have found by experience, having put in a Muslin Rag Ants, at the bottom of such fumed Corn, but they were not killed thereby. I

I have fumed whole Malt thus very strongly; and then being ground, brewed with it; it gave no Taste to Beer, that I could perceive. The probable effect of fuming it will be, that it may prevent the Beer's working too fast: For this is well known to be the effect of such Fumes on Wine and Cyder.

I fumed thus also some Sea-Biscuit, Pease and Wheat, in a large glass Vessel, which was repeated again after ten Days; yet they had no ill Taste: And exposing them for some time to the open Air, would probably free them from the very little Taste it gives. I sowed the Pease, which grew, so that the vegetative quality of them was not spoiled; but the vegetative quality of the Wheat was thereby wholly destroyed, for none of it grew, tho' sown three several Times, at some Weeks distance. It will not therefore be adviseable to fume Corn thus, which is intended to be sown. Tho' it will probably prove an effectual means to preserve Corn that is to be eaten: Which will be of great use, especially in hot Climates, where, I am informed, that the Corn is in great quantities spoiled by this Vermin.

When

When the *Weevel*, &c. have got into a Cask of Bread or Corn, there is no doubt but that thus fuming will destroy them : But it is doubtful whether their Eggs will thereby be spoiled : If therefore on experience it shall be found, that young ones are hatched from those fumed Eggs, in some little time ; then, if these last hatched Weevels are destroyed by another Fumigation, before they live long enough to lay Eggs ; this will be a means to prevent their increase for a long Time : But I think it probable, that if the fumed Casks are so close as to admit no fresh Air, that the Eggs will scarcely hatch ; or if they do, that the very tender young ones, cannot live and thrive, in such an Air.

Since the vegetative Quality of Wheat, is destroyed by the Fumes of burning Brimstone, a Hint may hence be taken, for an improvement in making of Malt, *viz.* By thus destroying the vegetative Power of Barley ; which may probably be done, by laying it on the Kilns, and burning a good quantity of Brimstone under it, for half an Hour, or an Hour ; the Fumes of which will ascend thro' it, tho' laid to any degree of thickness. And if they shall be found to have the same effect on Barley as on the Wheat, then the Root of the

the

the Barley will not shoot ; and consequently so much less of the Substance of the Grain will be exhausted in Malting, on which account, the Malt will be proportionably better. This may first be tryed by fuming only a handfull of Barley well, and then seeing if it will grow when sown in the Earth, or put in Water. Great care must be taken, not to come near the upper part of the Kiln while the Brimstone is burning, lest they should be instantly suffocated.

DIRECTIONS

F O R

Salting ANIMALS whole,

I N O R D E R

To make the FLESH keep Sweet
in hot CLIMATES.

DIRECTIONS

F O R

Salting ANIMALS whole,

I N O R D E R

To make the F L E S H keep Sweet
in hot C L I M A T E S.

AS the Difficulties and Hardships which sea-faring People labour under are many and great; not only on account of their being reduced to the great straits of a very short and scanty Allowance, of wholesome fresh Water; and sometimes perishing for want of some to drink: So are they also oftentimes put to great Difficulties and Hardships, for want of wholesome Provisions to eat, especially in long Voyages, and in hot Climates, which often occasions the spoiling of their salted Flesh, by the evaporating away of the Pickle, whereby it either becomes putrid and stinks, or is exceeding hard and dry, with little or no nourishing Virtue in it, causing thereby dangerous Scurveys. I hope therefore, the following Directions, for making Flesh take Salt very well,

in the hottest Climates, will be of great service, by showing them how to provide themselves with it there, when they have occasion, either thro' the badness or want of such Provision.

I have met with several who not understanding Anatomy, have looked on the Operation, as too difficult to be brought into common use: But on the contrary it will be found on Trial, most easy to do. I have by once showing, directed a common Butcher how to do it; and the Surgeons on Ship-board can soon instruct any one, how it is to be done. And Necessity, which is said to be the Mother of Invention it self, will soon, doubtless make Men expert, in performing a thing already invented. And I am informed, that it has already been put in practice in a hot Climate with success.

A sufficient quantity of Brine or Pickle must be made with common Salt, in the proportion of two Pounds and a half of Salt, to a Gallon of Water, which when boiled and scumm'd, will be nearly in the proportion of three Pounds of Salt to a Gallon of Water; which is the most that, that quantity of Water can dissolve; so that if there were more Salt in the Water, there might be danger

ger of its not entering in an undissolved state, into the fine Blood-Vessels.

The quantity of Salt, in half a Pound of *Mediterranean* Sea-Water being 128 Grains, *i. e.* $\frac{1}{27.3}$ of the whole, and a Gallon of Water weighing ten Pounds and three Ounces, there is in a Gallon of Sea-Water, five Ounces, three Drams, and twenty-eight Grains of Salt; which is about the ninth part of the Salt, which a Gallon of Water can dissolve. Hence we see, to how great a degree, a very salt piece of Beef, may be freshened, by being laid to soak in Sea-Water.

In order to salt an Ox whole, it will be convenient to provide forty or fifty Gallons of Brine or Pickle: For what is not injected into the Arteries, will serve to put the pieces of Flesh in, being first made stronger than with only three Pounds of Salt to a Gallon, as is done at the *Victualling-Office*.

For a Hog, Sheep, or Deer, provide five or six Gallons of Pickle; when you intend to use the Pickle, let it be made pretty warm, and have some cold by you, to bring it at once to a due Temper, *viz.* something more than blood-warm. If it were cold, by contracting the Blood-Vessels, it would probably pass with more difficulty: And for the same

Reason it is adviseable to infuse the Brine as soon as the Animal is dead, lest when cold and stiff, it should not be able to penetrate thro' the rigid and contracted Vessels.

Let the Animal bleed to death by cutting the *Jugular* Veins, whereby more Blood will be evacuated, than in the common way of knocking them on the Head, and then cutting their Throats, and the Flesh having by this means less Blood in it, it will the better keep on being salted. If you happen to cut a large Artery, tye it up, by drawing a Pack-thread round it with a crooked needle, else much of the Pickle will be wasted thro' it. If the Creature has done bleeding before it be quite dead, as will sometimes happen, then hasten its death by a blow on the Head.

Then laying the Animal on its Back, a little inclining to its right side, open its Belly, and turning the Caul and Bowels from the left Side; find the great Artery where it lays close to the left Side of the Back-Bone, at the small of the Back, below the Kidneys. And having cleared the Artery of the Fat, and thin loose Skin that covers it cut it half asunder a-cross; and then slit it, with a pair of Scissors, length-ways, a little more than the length of the short end of the brass Cock *E. D.* [*Fig. 1.*]; then thrust

thrust into the Artery, towards the Heart, the longest end of the Cock *B. E.* so far that the shorter end *E. D.* may enter the other part of the Artery : Then having with a crooked Needle passed pieces of Packthreads under the Artery between *B. E.* and *E. D.* tye the Artery fast to each end of the Cock *B. D.* If in an Ox the Share-Bone, be opened carefully with a Cleaver, just over the Bladder, it will be easier to come at the Artery, the Belly being thereby opened the wider.

For an Ox, the Diameter of the Brass-Pipe *B. D.* may be near half an Inch ; and the length of the end *B. E.* four Inches, of *E. D.* two Inches ; For if both ends were of an equal length, it would be difficult to fasten each end of the Artery, because the slit of the Artery must be so much the longer to give room for the end *E. D.* to enter it.

For Sheep, Hogs, or Deer, the Diameter of the bore of the Brass-Pipe *E. D.* may be almost two tenths of an Inch ; the longest end *B. E.* two Inches and a Quarter, and the shortest end *E. D.* one Inch and half, each end running taper, thereby the better to enter the Arteries ; with a swelling and nitch at *r. r.* as in the Figure here referred to. There-

by to prevent the tied Arteries from slipping off at either end.

Then having a linnen Rag twisted and tied round the upright end of the Cock *A*. thrust it fast into the end of a Spanish-Reed or hollow Cane, tying it fast. The Cane to be eight or ten feet high for an Ox, and five or six Feet for a Hog, Sheep or Deer, these heights being nearly equal, to the height to which the Blood is raised in these respective Animals, by the force of the Heart, as I have shown in my *Second Volume of Statical Experiments* : I have therefore chose herein to imitate Nature, by making use of a Force nearly equal to that with which, the Blood is by the Contraction of the Heart, drove thro' all the Blood-Vessels of the Body ; but perhaps a much less force may do, which those who have opportunity will do well to try.

When I reflect on the great Number of Experiments of this kind, which I had made several Years before on Animals, it seems very natural thence to have fallen on this Method of salting Animals whole ; yet I did not think of it, till several Years after ; when upon a sea-faring Man's telling me, of the very bad stinking Flesh, they were sometimes obliged to eat at Sea ; it presently occurred
to

to my thoughts, that Flesh might be made to take Salt in hot Climates, by thus infusing Salt Pickle through their whole Substance.

Care must be taken in tying the Cane above, to some proper support, that it hang so true as not to distort the Artery, by too much raising or depressing either end of the Brafs Cock *B.* or *D.* whereby the small branching Arteries, which go from the great one, to each Rib may be over-strained or broken, which would disorder the Experiment, and cause a great waste of the Brine thro' the broken Arteries.

The long Reed or Cane being thus fixed to a proper support, with a Tunnel in the top: First stopping the Cock, fill the Tunnel and Cane with blood-warm Brine, then open the Cock, and the Brine will flow freely thro' the whole Substance of the Animal; the Tunnel must be kept constantly filled as the Brine subsides. And if by any Accident the Tunnel and Cane are empty, then stop the Cock again, till they are re-filled, otherwise Air will be drove into the Arteries with the Brine, which will hinder the entrance of the Brine into the finer Vessels: by this means you will find the Brine flow and insinuate itself into every part of

the Animal's Body in the same manner as the Blood does, it being conveyed by the same Vessels; and this you will soon be convinced of, by making a small cut, in any of the extremities of the Body, as the Nose, Tail, Ears, or Feet, at any of which Places the salt Brine may be tasted.

I have observed that during the Operation, the Brine flows to waste too freely, thro' the Windpipe, and cut *Jugular Veins* of Sheep, and probably it may be the same in Deer, tho' it does not flow there so fast in Oxen or Hogs. But this may be prevented by putting a Cork into the Windpipe, and by tying a Cord hard round the Neck, to stop the Veins.

I have let the Brine flow thus, into the Arteries of an Ox for half an hour, and into Hogs and Sheep for a quarter of an Hour; which is doubtless a due time, when the Flesh is intended to be thoroughly salted afterwards with dry Salt, when cut in small pieces, in order to keep it long for Sea-Service; and probably Experience may show, that a much less time will suffice; for if once the Flesh be thoroughly soaked with Brine, it will doubtless imbibe dry Salt, fast enough, to preserve its inmost Parts from putrifying,

ing, even in the hottest Climates: For Flesh thus prepared, is observed, to imbibe Salt, much faster than other Flesh.

But I believe, the flowing in of the Brine for a much shorter time, may be sufficient, to make Flesh keep a few days, for the use of a Family at Land, or for a Ship during the first part of its Voyage, putting it into a strong Pickle: But if it be to be kept many days, it must be rubbed first with dry Salt, and layed to drain a few days, as is done at the *Victualling-Office*, where they cure the Flesh in the following manner, *viz.* they first rub it with white Salt only; then put it into Brine for five days to drain the bloody part out, for 'tis the Blood that is most apt to putrify: Then they pack it in Casks, strewing white and *Bay* Salt between each laying; then fill the Cask up with Pickle made of Water and Salt boiled so strong as to bear an Egg: They put three Pounds and half of Salt to a Gallon of Water. The proportion of Salt, Pickle included, is, to an hundred Weight of Flesh, four Gallons and a half of white, and one and a quarter of *Bay* Salt.

The Pieces thus salted with dry Salt, after the infusion of the Brine or Pickle, must be
laid

laid to soak for some time in Water, before they be used; else they will be apt to be too salt: The dry Salt, as before observed, soaking very fast, into the thus brined Flesh; so that there is not the least danger, of its not keeping sweet; there seeming rather, to be more danger of its being by this means too salt: Which may doubtless by further Experience be better regulated and proportioned, to the longer or shorter time it is intended to keep it.

I will here give an Account of the event of some Trials which I made, having salted whole in this manner, four Hogs, three Sheep, and two Oxen.

I find that Flesh salted in this manner requires much boiling, it being very moist and full of Gravy, tho' well tasted. It is too salt to Broil or Roast, with only the infusion of Brine.

I have found a piece of it, which had only the Brine injected thro' the Arteries, keep sweet ten Days, tho' hung up in the Chimney-corner, yet sometimes it would not keep sweet so long. An argument that it may probably be good in hot Climates for a few Days, without the addition of dry Salt, and some Days longer with a small sprinkling of some dry Salt, especially if put into strong Brine.

When

When salted well with dry Salt, which the Flesh imbibes most freely, it will keep long, even tho' heated much with hunting, just before it is killed : As I found by the Flesh of a Sheep, which was purposely hunted by a muzzel'd Dog for twenty-five Minutes. From whence we may reasonably conclude, that Flesh thus salted, will take Salt, and be preserved good, even in the hottest Climates.

Beef and Mutton thus salted, eat very well, as also Pork.

The Ox which was thus salted, the 17th of April 1736, at the *Victualling-Office* on *Tower-Hill*, before several of the *Lords* of the *Admiralty*, and *Commissioners* of the *Victualling-Office* ; having its jugular Veins cut asunder, there flowed out eighteen Quarts and a Pint of Blood *Winchester* measure, in forty-one Minutes, which Blood weighed forty-six Pounds and a quarter.

After the Brine had flowed freely for some time, with the force of a Column of Brine eleven feet high ; some of it came frothy thro' the Windpipe, from the Lungs, but what came from the Nostrils was clear.

The Brine flowing in thus, freely, for about half an Hour, the Body of the Ox was greatly swelled all over, There was about forty Gallons

Gallons of Brine used, much of which was wasted, tho' a great deal of it had soaked into the Flesh and Fat, the quantity of which would have been greatly increas'd, in proportion as the Operation had continued longer. Some of the Brine ouzed into the Stomach and Bowels.

The Ox by estimation of experienced Butchers, who are well known to guess pretty nearly to the Truth, weighed five hundred and a half. But with the Brine in it, it was found to weigh eight hundred, one quarter and eighteen Pounds: So that it increased in weight, on account of the Brine, two hundred, three quarters and eighteen Pounds.

The Carcass had not wasted above two Quarts, in hanging whole two Nights: But in cutting into small four-Pounds pieces, it wasted fifty two Pounds more, by draining off of the Brine.

I procured from the Victualling-Office, an Account of the event of this Experiment on the Ox, *viz.* Two Casks of this Flesh, which was not salted with dry Salt, soon stank to a very great Degree; as I also found in several Instances, that Flesh thus salted with Pickle only, would not keep many Days, without being also further salted with dry Salt.

The

The Flesh of two other Casks of the same Ox, which was salted with dry Salt before it was packed in the Cask, being examined eighteen Months after, and a Piece of it being boiled, it was judged not fit for Men to eat, as its Juices were entirely eat up by the Salt, and it fell in Pieces like rotten Wood.

Whence we see that it was over-salted: It will therefore require further Experience to adjust the Degree of salting for the use of Ships, in hot Climates. I kept some of the Mutton of the Sheep that was hunted, and thus salted full six Months, which proved good, and was not too salt, when layed first to freshen a due time in Water.

It has been suspected, that salting the Flesh thus, while hot, may be some disadvantage to it, as to long keeping. It may therefore be well to try whether Flesh can be thus salted when cold: But 'tis to be feared, that in hot Climates, where only this Method is like to be of use, Flesh will stink before it is cold.

If any in hot Climates, shall desire only to salt one half of an Animal, it may easily be done, by stopping one end of the Brass Cock, and fixing only the other end
of

94 *How to salt Animals whole.*

of it into the Artery ; so as to have Brine flow only through the Artery, that leads either to the fore or hinder half ; by which means, part may be eat fresh, and the salted part, the following Days.

If any should desire to keep a part of hunted Venison a few days, or to send unhunted Venison to a great distance in hot Weather, it might probably be done, by only thus injecting into the Arteries a little Brine ; which might not disqualify it for Pasties or Boiling.

I have been told, that in order to preserve Flesh, in the hot Parts of *America*, they dip thin Cutlets of it, in Sea-Water, and lay it on Rocks to dry, which makes it look like Glew-Cakes; and is called *Jerked* Flesh.

A N
A C C O U N T
O F

Some Experiments and Observations
ON CHALYBEATE WATERS.

A S A L S O O F

Some A T T E M P T S to find out Means to
have them *Conveyed* to distant Places, with
a greater degree of MINERAL VIRTUE
than has hitherto been done.

He will Bless thy Waters. Exod. xxiii. 25.

A N

A C C O U N T

O F

Some Experiments on CHALYBEATE
or STEEL-WATERS, &c,

MAnkind are blessed with innumerable of these genuine salutary Cordials of Nature, in almost all parts of the World; which have been found so very beneficial in many Cases, for procuring and establishing of Health, that much inquiry has been made into the nature of them by Physicians, who have from time to time, written many Books on this Subject; and given Directions how, and in what cases they are to be used. I am only acting herein the part of a Naturalist; it were presumption in me, to attempt to invade their Province, for which I am in no degree qualified.

Did I indeed hereby seek only popular applause, and not the real benefit of Mankind; the more ignorant I was in Physick, the bet-

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ter

ter chance I should have, to be much cryed up by the unknowing Many: The Truth of this, we may have had full proof of, of late Years, in the Instances of several most ignorant Quacks; who have in their turns had a more general Cry of Applause given them, than has come to the share of the most eminent and skilful Physicians, with many of which that Faculty abounds. But the Physicians may well be content to take this contempt the more patiently, when they reflect that a petulant fondness for Quackery is the epidemical Disease of this Age; not only in opposition to theirs, but also to other Professions. Did I therefore thirst after such kind of popular applause; I should have a fair opportunity to obtain it; by crying down, under the Cover of a few new Experiments, the ancient Sages and Establishers of the Science of Physick as Impostors, and the modern ones as ignorant Cheats. 'Tis in the like base disingenuous and profane manner, that the daring conceited Denyers of the Lord that bought them, those Quacks in Religion, treat the great and important Truths of it. And thus every Wiseacre State-Quack takes upon him to censure the most prudent and unexceptionable Conduct in State-Affairs.

The

The particular Occasion of my ingaging in the following Experiments, notwithstanding I had for some Years before purposed not to meddle any farther in *Philosophical Researches*, was owing to a dangerous Fit of Sicknefs, about five Years since ; for the recovery of which, my Phyfician very judiciously sent me, to drink the Chalybeate Waters of *Sunning-Hill* in *Berkshire* ; where I, as well as feveral others whom he advised to drink those Waters, found great benefit, by recovery from dangerous Diseases. And in order to fill up, and amuse away a few of the many vacant Hours, which such Places both occasion and require ; I resolved, by such proper Experiments as should occur to my Thoughts, to try if I could find, the subtile sulphureous Spirit, in which I concluded, as it has been generally thought, that the principal Virtue of Chalybeate Waters resided.

And in order to it, I filled several *Florence* Flasks, which contained about three Pints, with the Steel Water, and inverted their Noses when full, into earthen Mugs full of the same Water ; and set several of them in a Boiler full of that Water, in the same manner as in Exper. LXVI. vol. 1st. of my *Statistical Essays*, I had got the quantity of elastick

Matter out of several Waters. I set the Boiler on the Fire, and having given the Water a scalding heat; an elastick Aerial Air-Bubble was by this means formed in the upper part of the inverted Flask, which was nearly equal to $\frac{1}{4\frac{1}{2}\frac{1}{2}}$ part of the bulk of the whole Water, and near double the size of an Air-Bubble, which arose at the same time, from a like quantity of common Water. The yellow Ocry Mineral adhered very fast to the insides of the earthen Mugs; as is usual when Steel-Waters are heated in them.

I poured the Air, or elastick Spirit, of one of the abovementioned heated Flasks, up into an inverted Half-Pint full of common Water which had been boiled, to clear it of its Air; and then shook it to and fro' to make the elastick Matter incorporate with the Water, to which, yet, it communicated no mineral Virtue, nor would it tinge with Galls. A probable Argument, that there is little or no Virtue, as has been thought, in this subtile elastick Spirit.

Being desirous to see what quantity of this Elastick Aerial Matter would rise from this Water, without Heat, I filled an inverted Flask with it; and let it stand thus, nine Days; in which time a few Air-Bubbles a-

rose to the upper part as big as half Tares, which were in standing longer, reformed again into the Water. I found this Water tinged very well with Galls; nor had it deposited any Sediment or Flocky Thrumbs, as this, and most other Chalybeate Waters are apt to do, in standing one, two, or three Days, in any Vessel or Bottle corked in the common way.

But if in first inverting the Flask, an Air-Bubble of about half an Inch Diameter were left in the upper part, then the mineral Water soon lost its Virtue of tinging with Galls; and deposited a Sediment, which was sooner or later, according as the Diameter of the Bubble was less or greater. And accordingly Dr. *Burton* of *Windsor*, who joined with me, in several Experiments on *Sunning-Hill* Water, observed at the same time, that the narrower the neck of the Flask was, in which he kept these Waters with the neck uppermost, they would accordingly retain their mineral Virtue, somewhat the longer: I found also that the Virtue of many other Chalybeate Waters, might be thus long retained in inverted Flasks viz. Those of *Oakingham* in *Berkshire*, *Cobham* and *Chobham* in *Surry*, *Midhurst* in *Sussex*, *Bramshot* and *Southampton*, in *Hampshire*, *Tunbridge* and *Islington*. But the

Chalybeate Waters of *Hampsted, Middlesex*, and *Frensham in Surrey*, did not retain their tinging Virtue by this means. Tho' with tubulated Corks, the tinging Virtue of the *Hampsted* Waters was long preserved at *Hampsted*.

Galls are commonly made use of to prove, whether any Waters have, or retain their vitriolick Mineral, because it is a Quality peculiar to vitriolick Salts, thus to tinge with Galls, or other astringent vegetable substances. Not that Chalybeate Waters have any true mature Vitriol in them; for that is formed only, from the metallick Chalybeate Salts, in the open Air; and cannot therefore be generated under Water.

Finding therefore the manifest effect, that the contact of the Air, on the surface of the mineral Water, had in precipitating the Virtue of the Water, by promoting a putrefactive agitation in the Water; I thought of the following Method to prevent the Air's touching the Water in common Bottles; and yet without any danger of bursting the Bottles, *viz.*

I provided several glass Tubes, about seven or eight Inches long, and about one tenth of an Inch Diameter in Bore: I chose some of the best and least porous Corks I could get; and having burnt Holes thro' them from end

to end, with a round-pointed hot Iron ; then with a round File I filed the Holes to such a size as fitted each glass Tube. Then having provided some melted Cement, made of equal quantities of Whiting, Bees-Wax, and white Rosin, which will give no ill Taste to the Water ; the Tube having the Polish rubbed off at one end, for an Inch and half, on a wet Brick, that the Cement might stick the better ; it being first warmed, was appointed with Cement, and then immediately thrust into the Hole in the Cork, so as to stand out full half an Inch above the Cork at *F*, fig. 2. whereby hold might be taken of it, with a wet piece of Pack-thread, tyed round it, to pull the Cork out of the Bottle, if need required, for it cannot be done with a Bottle-screw.

Then having filled the Bottle brim full at the Spring-Head, and the tubulated Cork being well wetted, and rubbed under Water with the Fingers ; to clear it of any small adhering Air-Bubbles, thrust the Cork into the Bottle ; yet so that the glass Tube may not touch the bottom of the Bottle at *H*, lest it should thereby be broke, or hinder the entrance of the Cork, to its due degree. And thus all access of Air, to the Water in the

Bottle, is intercepted, except that the Air touches the Water, on its small surface in the upper end of the Tube at *i*. And the glass Tube being open at both ends, the Water can easily rise and fall in it, in proportion as the Water in the Bottle dilates and contracts, by the different Temperature, as to the warmth or coolness of the Air; whereby the danger of bursting the Bottle is prevented, which it would do by the dilatation of the Water, if a common Cork, which immediately touched the Water in the Bottle, were tyed fast down. But the Diameter of the Inside of the glass Tubes, must not be very small and fine; because it could not then contain Water enough, in proportion to the sum of the Contraction of the Water in the Bottle, and consequently some Air would rush in thro' the Tube, and spread itself between the Water and the Cork.

When the Water in these Bottles with tubulated Corks, is to be carried to some distant Place, the Corks should be tyed down, else if they be loosen'd at all, the Air is apt to get in thro' the Tube. And when they are packed up for Carriage, they ought not to be put with their Noses downwards, but upright, or not above half reclining.

I found that by this means, the mineral Virtue of several Chalybeate Waters might
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be preserved for many Weeks, without its precipitating to the bottom and sides of the Bottles. But if any Air got between the Cork and the Water, then, that Air by its incessant elastick Action, promoting some degree of agitation or ferment in the Water ; causing the Mineral Particles thereby to disintangle themselves from the Water, and to coalesce into new Combinations, of so much larger size, as disqualifies them to be any longer suspended in the Water ; they then precipitating to the bottom and sides of the Bottles, partly in the form of a yellowish Ocre, and partly in cloudy Flocks or Thrumbs ; the Water thereby becoming effœte and vapid.

But I observed in the Instances of many Chalybeate Waters, that if after they had thus precipitated their Mineral Virtue, they stood till they had putrified thoroughly, for small degrees of Putrefaction will not do, it must be so great, as to have attenuated their deposited ocry Sediment, by that most subtile dissolvent Putrefaction, to that degree of fineness, as to be fit to be taken up, and be intimately incorporated with the Water ; that then the Water gave as good a Tincture with Galls, as when first taken from the Spring : And as this was observable in many Chalybeate

lybeate Waters, so it is a probable Argument, that the principal Virtue of these Waters consists in their Mineral Particles being in a fine attenuated State ; and not in a subtile volatile Spirit, as has been thought. If there were such a Spirit, it could not fly off from the Water, which was confined in the *Florence* Flasks turned upside down, unless we can absurdly suppose it to penetrate and escape thro' the Glass. Now a Chalybeate Water loses its Virtue in an inverted Flask, as soon as in a common corked Bottle, provided a small Air-Bubble be left in the Flask.

The late Dr. *James Keill* of *Northampton* told me, that notwithstanding he hermetically sealed up, or melted close up, the Nose of a *Florence* Flask, full of a Chalybeate Water from a Spring near *Northampton*, yet it soon deposited its Sediment, and would not tinge with Galls, *viz.* because there was an Air-Bubble left in the Neck of the Flask ; for he could not seal it up without leaving an Air-Bubble. But if the Virtue of this Water consisted in a volatile Spirit, which was apt to fly off ; it had in this case, no way of escaping, but thro' the Substance of the Flask, which is very unlikely.

To conclude that the principal Virtue of Steel-Waters consists in a volatile Spirit, because they have a Chalybeate Sulphureous Smell, seems as unreasonable, as to conclude that the Virtue of many Medicines consists principally, in their volatile odoriferous Vapour, rather than in their other manifest Qualities. It is well known that several medicinal Preparations of Steel, have nearly a like effect, with that of Chalybeate Waters, on those who use them ; and yet it is not thought that their efficacy lays in a subtile Spirit ; but in more manifest Qualities.

I will here insert an Observation, *viz.* that the Scales which fly off red-hot hammered Iron, when put into Water, will give no Tincture with Galls to that Water, as Filings of Iron will do. An Argument that the vitriolick Virtue of those Scales is destroyed by the gross Sulphur in the burning Coals, in the same manner as common Brimstone destroys or demetallizes Iron, when melted by it in a red-hot state.

The above-mentioned Dr. *Burton* carried some Bottles of the *Sunning-Hill* Water with such tubulated Corks to *Windsor*, which is about five Miles distance ; where they retained

tained their tinging Virtue with Galls for several Weeks.

And the Rev. *Mr. Archdeacon Brideoake*, sent by Water at my desire a Steel Water, in Bottles with tubulated Corks, from a Spring near *Southampton*, to *Dr. Bateman* at *Winchester*, which is twelve Miles distance, which Water, as the Doctor wrote me word, retained its Virtue of tinging with Galls, and its ferrugineous Smell, for several Weeks.

Dr. Langrish of *Petersfield* in *Hampshire* told me that the Steel-Water at *Cosse's-Mill* near *Midhurst* in *Sussex*, being sent him thence by his Brother to *Petersfield*, which is seven Miles distance; did by means of these tubulated Corks, retain its Virtue of tinging with Galls a Year after. But 'tis probable, that this Water in so long keeping, had putrified and become sweet again. When Water begins to putrify, it tinges less and less with Galls, and at last not at all: But when the Putrefaction proceeds to a greater Degree, then the mineral Particles are so attenuated, as to be fit to be resorbed and re-incorporated with the Water, in the same manner as when in the Spring, as was before observed; and the tubulated Cork contributes to keep it in that state, by excluding the Air.

Dr. *Nesbit* also preserved *Isslington* Steel-Water clear, and with a tinging Virtue, for several Weeks, with these tubulated Corks, at his House in *Basinghall-street*; whereas it is well known, that this Water soon turns foul, when carried but a little way from the Spring. He observed also that a Bottle with Oil on the Water, but without a Cork, tinged well, after standing eleven Days at *Isslington Wells*.

As to *Bath* Water, one whom I desired to try how long its tinging Virtue might be preserved in inverted Flasks at *Bath*, wrote me word, that after standing thus thirty-eight Days, it gave a purple Tincture with Galls; perhaps it had putrified, which regenerates its tinging Quality; *Bath* Water gave a much stronger Tincture when it had been in an inverted Flask only three Days. Yet others say, they found no such effect on the like Trial.

Dr. *Harrington* found that *Bath* Water, after being preserved two Months in Bottles with tubulated Corks gave a sensible Tincture with Galls. And some *Bath* Water, which the Doctor sent me to *Teddington*, in Bottles with tubulated Corks, with a little Linseed Oil in the Tubes, to prevent the Air's touching the

the Water, gave a faint blush with Galls, and after fourteen Months keeping, this Water immediately gave a whitish Colour; whereas *Bath* Water, tho' after some Days it becomes greenish with Galls, yet when kept in Bottles corked in the common way, it gives no more Tincture with Galls than common Water: A probable Argument that these tubulated Corks are of use in preserving that Water, with at least some small Degree of Virtue, more than in the common way.

And it is further observable, that when I opened one of these tubulated Bottles, the Water would not only give this milky colour with Galls, when first opened, but also for many Days after, tho' the Bottle wanted of being full. And Dr. *Nesbit* observed the same of *Islington* Water. Hence we have a good Hint to try whether it would not be better, that *Bath* and other Steel-Waters should stand in a cool Cellar, in Bottles with tubulated Corks, for some Days, before they be convey'd to distant Places. For since the mineral Principles of *Islington* Waters, by thus standing for a considerable time, acquire so great a Degree of Stability, as not to be precipitated in several Days, by the Action of the Air on the Surface of the Water, in Bottles which

which are in part emptied : It should therefore seem probable, that they will be less apt also to be precipitated, by the Agitation of long Carriage, than if carried away immediately after the Water is bottled.

I have had also several other Parcels of Water from *Bath*, with tubulated Corks; the Water of some of which, was as good as that sent me by Dr. *Harrington*, and some no better than that which is brought in common corked Bottles, tho' no Air-Bubbles got into the Bottles, which they are but too apt to do in so long a Journey. Yet notwithstanding this uncertainty of Success, it may sure be worth the while, for some curious Persons, when they shall have occasion for *Bath* Water at distant Places, to make use of these tubulated Corks, which will not much increase the Trouble or Expence ; and yet may possibly be the means of farther improving the Method of conveying Steel-Waters, somewhat better conditioned, to distant Places. And Linseed Oil was preferred before Oil of Olives, because it will not harden with cold as the other Oil will ; which, by stopping thereby the Orifice of the Glass Tube, might indanger the bursting of the Bottles. 'Tis probable that these tubulated Corks might be of some service in carrying

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ing *Bath Water*, by water to *Bristol*; and I intended to have had some brought by Sea to *London*. The way to succeed in useful Improvements, is to persevere, and not to be discouraged at a few disappointments. But as *Bath Water* when once cold, loses a principal part of its Efficacy, which cannot be recovered by warming again, so it were vain ever to hope, to have it conveyed to distant Places, with any degree of that Efficacy thus lost.

I could not succeed in several Attempts to bring *Sunning-Hill Water* in tubulated Bottles on horseback to *Teddington*, which is twelve Miles; nor *Midhurst Steel-Water* to *Farringdon* in *Hampshire*, which is twelve or fourteen Miles. Nor could I succeed in several Attempts to bring *Tunbridge-Wells Water* good to *London*, by means of tubulated Corks; tho' very carefully secured by *John Hooker Esq*; of *Tunbridge Town*, to whom I am obliged for communicating to me many Experiments and Observations which he made on those Waters. But though we could not convey them thus to *London* good conditioned in the Summer part of the Year; yet since in the Winter part of the Year, he observed these Waters to keep pretty good
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for Months, even in Bottles uncorked, and longer when corked, but not when they were half full: Hence in the Winter part of the Year, we might hope for some better Success, in carrying them to distant Places with tubulated Corks.

The Steel Water at *Frensham* near *Farnham* in *Surrey*, which presently gives a fine Tincture with Galls at the Spring, did not retain its tinging Virtue, with a tubulated Cork, tho' the Bottle was not removed to a distant Place, but stood in a House near the Spring. As this Water comes out of a very soft Sand, so I suspect that its great proneness to precipitate its Mineral Virtue, is owing to the finer part of this fine dusty Sand, which by its weight precipitates it, in the same manner, as it is well known to fine down Wine or Cyder.

The Steel-Water near *Claremont*, in the Parish of *Cobham* in *Surrey*, which springs out of a pure white Sand, retains its tinging Virtue well for Months in tubulated Bottles, kept in the adjoining House; but it loses much of its tinging Virtue, and proportionably precipitates its Mineral Sediment, in carrying no farther than to *Hampton-Court* or *Teddington*, which are but four and five Miles distant. So that notwithstanding the Air is intercepted from acting on the Water in the Bottles, by means
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of the tubulated Corks, yet the Agitations in so few Miles carriage, gives the Mineral Particles so much Motion, as to cause them to combine and precipitate; and the warmer the Weather, the more apt they will be to do so.

This Spring in *Cobham* Parish, is lately opened by *James Fox* Esq; the Lord of the Manor, and made commodious with some Buildings, for the use of such as come to drink of its Waters.

These tubulated Corks can be of no service in preserving the Mineral Virtue of *Pyremont*, *Spa*, or the like Waters, which abound with an elastick Aerial Spirit; and which rising in great quantities from such Waters, will soon form an Air Bubble, between the Cork and the Water; which totally defeats the use of these tubulated Corks.

Thus have I given a short account of what these tubulate Corks can, and cannot do; as well in order to explain what Influence the contact of the Air, on the Surface of the Water, has towards promoting the Precipitation of the Mineral Virtue of these Waters; as also in hopes, that they may in some Cases be of use, at least for Persons who live at small distances from such Waters.

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For tho' Mineral Waters must ever be best when drank at the Spring-Head, when their Mineral Particles are in the most subtile and attenuated state; and consequently fittest to enter the capillary Vessels of the Body; yet when in cases of Sickness, bad Weather, or other Incidents, a Person cannot go to the Spring, it may at least be of some advantage, towards preserving some farther degree of Virtue than can be done without such means: For it is a common Observation, that *Bath* and *Tunbridge* Waters sensibly abate something of their Virtue, by being drank at a little distance from the Spring. The Truth of which may be further confirmed by the following Observation, *viz.* it is found by Trials on *Spa* and many other Steel-Waters, that a quantity of it, which has stood about half an Hour in a Glass, will tinge Purple with Galls sooner, than some of the same Water just taken from the Spring. A probable Argument, that the action of the open Air, on the Surface of the Water, has in so short a time, disposed the Mineral Particles to be in some degree disintangled from the Water, so as to be tending towards uniting themselves into larger Combinations: Which is agreeable to Monsieur *Geoffroy's*

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Observation,

Observation, *viz.* that the Tincture with Galls will be flower, the more intimately the Steel is dissolved in and blended with the other Mineral Principles of the Waters ; which seems to be the Case of the Steel-Water near *Claremont*, which is flower in coming to its full Tincture with Galls than most Steel-Waters that I have observed. Hence we may see how wrong a thing it is to have the Reservoir of Water at the Spring Head, I mean the Reservoir under the Stone Basins, too large, in proportion to the Quantity of Water, that flows from the Spring. A fault which I have observed in the opening of some Steel-Springs. For when the Stream is small and the Reservoir large, too great a Quantity of Water will stand there, stagnating and consequently losing its Virtue.

As to *Bath* Water, the tendency of it towards cooling, may of its self probably cause a proportionable tendency of the Mineral Particles, which abound in that Water, towards a coalescence into Particles of a somewhat larger size : And this Coalescence of the Mineral Particles, which is occasioned by the cooling of *Bath* Water, cannot probably be dissolved again, by reducing the Water to its first degree of Heat ; and accordingly it

is found, that *Bath Water* when once cold, tho' heated again, will not have the good effect, that warm Water fresh from the Spring has: Its more subtile Mineral Particles being probably absorbed by and incorporated into the calcarious matter which abounds in that Water.

Yet since, according to Dr. *Guidott's*, and other Observations, there are found about eleven Grains and a Quarter, of Mineral Sediment in a Pound of *Bath Water* evaporated to dryness; and since the Quantity of Sediment in a Quart of *Bath Water*, after it has stood long, is very small, so small as to make it be disputed, whether there be any Sediment; and since notwithstanding this great Quantity of calcarious, saline, nitrous and sulphureous Matter in this Water, it yet continues clear tho' long kept in Bottles, a probable Argument that its Mineral Particles are not combined in very gross Combinations: Since, I say, this is the Case, it should seem probable, that this Water, tho' kept for a considerable time in Bottles, should be better than common Water; which yet some are of Opinion that it is not.

But when by throwing in some Salt or Oil of Tartar, the Salt of Tartar seizes on

the nitrous and common Salt; then the copious calcarious Matter, being deserted by the nitrous and other Salt, which held it suspended and attenuated in the Water, immediately precipitates to the bottom, in the visible Form of a white *Calx*. The quantity of Sediment in one Hogshead of the Water of the King's Bath, taken from the Pump, in wet weather, and evaporated to dryness, was found to be, according to Dr. *Guidott's* Observation, ten Ounces five Drams and half; whereof five Ounces three Drams were Grit, two Ounces one Dram and half, a blue sulphureous Earth or Marle; two Ounces seven and a half Drams Salt. Of which more than two parts in three were common Salt, the rest Nitre. *Observation. LXI, LXIV.*

II.

I tried also whether the tinging Virtue of Steel-Waters could be preserved, by corking Bottles with tubulated Corks, whose Tubes stood upright above the Corks; by which means also, the Air could touch the Water only in the narrow Tube: This method succeeded very well with some Waters, but not with others; which I suspect was owing to the Bottles not being clean enough. For
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when the Bottles are not perfectly clean, and free from the Tartar of Wine, or Ocry Sediment of mineral Waters which have been in them, those Incrustations soon attract the mineral Virtue out of Chalybeate Waters, as also they are well known to spoil Wine, Cyder or Beer, put into such foul Bottles. The most effectual way to clean such Bottles, is to boil them in a Lye of Wood-ashes, as is done (by those who are careful) in bottling Wine, &c. I observed that the Water subsided very slowly in these Tubes, tho' they stood some Months; a proof that good Corks imbibe very little of any Liquor that touches them.

And since the Virtue of Chalybeate Waters may by this means be preserved, for several Days near the Spring Head, this method may perhaps be of some use at *Pyremont* and *Spa*. Which we have the more encouragement to attempt, because a considerable quantity of the Virtue of these Waters, is long retained in Bottles, when carried to very distant Places : Which may perhaps be owing in the *Pyremont* Water, especially to the great quantity of mineral and calcarious Matter which it contains, there being on evaporation of a Pound of it, no less than twenty-two Grains

of dry Sediment: And accordingly it has been observed of several Chalybeate Waters, that their Chalybeate Virtue is detained from precipitating, for some Days, by several things that inspissate the Waters. Yet I am rather apt to suspect, that a principal reason why *Pyremont* and *Spa* Waters retain their Virtue longer than any of our Steel-Waters in *England* will do, may be owing to the large quantity of saline matter in them, for Dr. *Seip* found in the dry Sediment of *Pyremont* Water, no less than seven Grains in twenty-two to be a white bitter Salt. And in *Spa*-Water the white alkaline Salt is in the proportion of eight Grains to ten, to the rest of the Ocry Sediment; so that as was above observed in *Bath*-Water, this proportion of saline matter, which is strongly attracted by the Water, contributes probably towards the keeping the mineral Virtue of these Waters the longer suspended in them. But if the mineral Virtue of *Pyremont* and *Spa*-Waters is sustained longer in these than other Waters, by means of the little invisible Air-Bubbles that abound in these Waters; then this method of Tubes, would do more harm than good, by depriving them of those Air-Bubbles: Which Air Bubbles being enlarged by warmth, may be the reason why *Pyre-*
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mont-Waters bear heating longer than other Waters, without precipitating their mineral Particles, tho' the great proportion of saline matter seems to me to be the principal cause.

I could wish therefore that some curious Experimenter and Observer would make the tryal; not with tubulated Corks, as above-mentioned; because it would be a difficult matter and endless trouble, to fit such Corks in a proper manner to every Bottle; and to cut the bottom of each Cork hollow like a Cone, to prevent the ascending Air-Bubbles from lodging there.

But in the following manner, *viz.* with a glass Tube which is formed at each end like a Tunnel: which Tunnels being of a sufficient size to cover the outside of the Nose of every Bottle; to which they must be fixed by means of some proper soft Wax, wrapped round the Nose of the Bottles, which are first to be filled with Water, before the Tube be fixed, which when fixed, must also be filled up as high as the narrow part goes, but no higher. The Diameter of the glass Tube which is between each Tunnel, must be full half an Inch; else if it be narrower, the Tube will be filled with the ascending Air-Bubbles, instead of Water, which will defeat the use of it. And as the Diameter of the Tube must
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be thus large, it will be adviseable to have it so much the longer, *viz.* about sixteen or twenty Inches ; that the influence of the Air on the surface of the Water in the Tube may be the longer before it reach to the Water in the Bottle : Besides, the longer the Tube is, the more difficult it will be for the subtile sulphureous Vapour to escape, which Vapour is observed to give a kind of vinous Taste to *Pyremont* Waters; and is a different thing from the sparkling Air-Bubbles, in which many are apt to think, the Virtue of these Waters does principally consist : Which sulphureous Vapour ascends in such quantity, that it not only sometimes intoxicates the *Waiters*, but in a dry Constitution of the Air, it kills Ducks which swim on that Water in a short time ; but does not incommode them in the least in a moist Air. Whence it has been falsely concluded that *Pyremont* Water abounds more with this sulphureous Vapour, in dry than a moist Air ; whereas the true Reason of its not killing Ducks when the Air is moist, is owing to the great quantity of Watry Vapour with which the sulphureous are then diluted and blended, which much abates their noxious Quality ; as I have fully proved in my *Analysis of the Air* ; see my *Statical Experiments* Vol. I.

Bottles

Bottles filled with the Water thus prepared, would not be so apt to burst, as the Dealers in those Waters complain they are too apt to do in the common method, notwithstanding they let them stand for some time open, for the elastick Air to fly off before they cork them; by this means, they might also with the more safety, be corked with a less quantity of Air under the Cork, which would contribute to the better preserving the Water.

I am sensible, that those who believe the Virtue of these Waters consists chiefly in their volatile elastick Air, or Spirit, as it is called, will think them vapid and spoiled by this management. But on the other hand it is not easy to conceive how such elastick Aerial Vapours should enter the finer Vessels of the Body, or if they did, they seem to be more likely to do harm than good: For these Waters which abound with such elastick Airey Vapours, are found to discompose the Head by filling the Stomach with Wind, more than other Chalybeate-Waters do: Those who are fond of drinking much Wind with their Water, need not be at the expence of buying *Pyrmont* or *Spa-Waters*; 'tis easy to put into common Water a mixture, that will produce plenty of sparkling Air. If therefore, on try-
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al, this method of preserving these Waters shall be found of any use ; it will I hope compensate for the imagined loss, in the want of the brisk Air, which flies off the Water in a sparkling manner.

Several who are curious Observers, have found that a considerable number of the Bottles of *Pyremont* Water, which they have used, tho' they have been very brisk and sparkling, yet have given no manner of Tincture with Galls or green Tea ; nor have they found any Benefit in drinking such effœte Water. And I have my self frequently observed the same thing. It would therefore be a good way to try every Bottle with Galls or green Tea, before any of it is drank. But it were unreasonable and unjust to lay any blame on the *Dealers* in those Waters, when in truth it ought to be imputed rather to the great difficulty there is in carrying Chalybeate Waters to very distant Places, with any degree of their mineral Virtue. The cooler the Weather, the more likelihood there is of success. I shall be glad if the method I have here proposed, may contribute any thing towards it.

I have found the size of the Bubble of Air, which has risen from a common inverted
Pyremont

Pyremont Bottle of that Water heated to be $1 + \frac{1}{8}$ cubick Inch, being tryed here in *England*; there would doubtless much more have risen from a like quantity of fresh Water at *Pyremont*: Some of the thus generated Air was again reformed by the Water, in standing some Days. And Mr. *Ed. Warkman* a Gentleman of *Leyden*, to whom a Friend of mine gave a Paper of some Experiments, which I desired to have tryed on *Spa* Water, found on tryal, that there arose in seven Days, from a Flask of the *Geronsterre*-Water, whose Nose was inverted into a Glass of the same Water, more than a cubick Inch and half. of elastick Air. And that the Water retained its tinging Virtue with Galls very well; but that it intirely lost that peculiar Smell and Taste, which it has when first taken from the Fountain; and retains only the Taste of the *Pobon*-Waters, but a little flatter: For which reason 'tis thought that it will answer no other end, when transported to distant places, than what the *Pobon* does much better. And Dr. *Chrouet* an antient eminent Physician at *Spa*, says in his printed Declaration, of the *Geronsterre*-Water, that its metallick Sulphur, in which its principal Virtue consists, is so very subtile, that it flies away, notwithstanding all pre-

precautions that can be used, in Bottling to prevent it. But it could not escape thro' the above mention'd inverted Glass Bottle; it must therefore be either raised and mixed with the elastick Air-Bubble, at the upper part of the Glass Bottle, or be reduced to a more fixed state, by uniting and combining with the other Mineral Principles in the stagnant state of the Water; which seems to me the more probable, for the tinging Virtue of the Water with Galls continued, notwithstanding what was raised from the Water, in that large Air-Bubble. And Dr. *Seip* of *Pyremont* wrote me word, that that Water retained its tinging Virtue, notwithstanding he had poured some of it, many times to and fro, to free it from its elastick Air, and subtile volatile sulphureous Vapour. He says that that Water keeps the better for having Oil on it in the Neck of the Bottle.

III.

I have made also some Attempts to preserve Chalybeate Waters with Glass Tubes, about six Inches long, which were open at one end, and had a small Bubble at the other end, of such a size that it could well enter a common Quart Bottle which had a
large

large Mouth. When the Bottle was filled with Water, the Tube was put into the Bottle with the Bubble uppermost; and the Bottle being brim-full of Water, a Cork of the best sort being first wetted to clear it of small Air-Bubbles, was pressed hard into the Mouth of the Bottle, and tied fast down: By which means the Air in the Glass Bubble was proportionably compressed by the Water which rose above half way up the Bubble: The remaining space in the upper part of the Glass Bubble, being left for some of the Water to ascend into, in case it should dilate, by any greater degree of Heat, than it had at first, which would otherwise endanger the bursting of the Bottle,

Dr. *Burton* found the tinging virtue of *Sunning-Hill* Water well preserved by this means at *Windsor*. And Mr. *Hooker* found that *Tunbridge-Wells* Water thus preserved at *Tunbridge Town*, which is six Miles distant, did sometimes succeed very well, and gave as fine a Tincture as at the Spring Head, after several Months keeping, and sometimes he had not the like success; and others as well as my self found the same uncertainty as to the Event: Which may be attributed to two Causes, viz. either the different

rent degree of warmth or coldness of the Weather, when the Water was taken up : Or else to the different degree of cleanness of the Bottles, which were made use of; for I met with many disappointments, before I was sufficiently aware of the importance of having the Bottles, as perfectly clean as if they were new. For if there be any Tartarine Sediment, adhering to the bottom of them, that is very apt to draw to it the Mineral Virtue of the Water ; in the same manner as the calculous matter of Urine will be attracted in greater quantity by a foul than by a clean Urinal, as also the Stones in the Kidneys or Bladder attract similar Particles from the Urine.

IV.

There is another way also which I made use of, by which the Air was absolutely secluded from touching the Water in the Bottles, in any the least part, *viz.* I chose some of the softest velvet Corks that I could procure ; and thrust five or six of them, into a Quart Bottle, they being first well wetted to clear them of adhering Air-Bubbles. Then filled the Bottles brim-full of Water, and thrust hard into the Mouth of it, a very
good

good Cork, tying it down firm. By this means no Air could touch the Water; and at the same time the Bottle was secured from bursting; because, as the Water dilated at any time with more warmth, the soft yielding Corks were proportionably compressed, to make room: for I found that by putting such Corks under Water in a Glass Vessel, and placing it in a Glass-condensing Engine, that on compressing the Air, it made the Water subside in which the Corks were immersed, by their yielding to the greater pressure of the Water.

I have by this means succeeded in preserving the Virtue of Steel-Waters, for six Weeks near the Spring: And sometimes not so long. I was at first apprehensive that the Corks might contribute, in some degree, to the spoiling of the Mineral Virtue of the Waters, they being turned black by it. But Dr. *Seip* assured me of the contrary, he having put an hundred new Vial Corks, into a three-pint Bottle of *Pyremont* Water, which being tried with Galls, after it stood a Month in his Study, it gave a very good Tincture: And Mr. *Warkman* found the same Event with *Spa* Water.

Thus have I given an Account of the several means which I made use of, for preserving the Mineral Virtue of Steel-Waters, hoping they may all be of some use, in different Circumstances; at least to convey some of these Waters a little way. Those who have not the convenience of Glass Tubes, may perhaps find some Benefit in the use of soft Corks.

As Heat is apt to spoil the Virtue of these Waters; it seems probable that it would be of some use, to cover the Bottles with Salt in a Basket in very hot Weather; this might be of use for carrying Bottles of these Waters to small distances, as from *Islington* to any part of *London*, &c.

When it is adviseable to drink Chalybeate Waters warm, I find it is better to warm them in a Bottle, with its Nose downwards than upwards: For I found by Trial at *Sunning-Hill* that when I put two Vials full of cold Water, into a Vessel of the same Water, and warmed it; the Water in the inverted Vial gave a better Tincture, than that in the other Vial which was not inverted: And only one Draft should be warmed at a time, for when warm, it soon grows foul and loses its Virtue.

As the Mineral Particles of Chalybeate Waters, are doubtless in their most subtile and attenuated state, and therefore most efficacious at the Fountains ; so it will ever be best to drink them there : But as this cannot in many Cases and Circumstances be done, it is therefore a Matter of great Importance for the Benefit of Mankind, to try if any means can be found out, to convey them to distant Places, with a good degree of their Virtue ; that is, with their fine Mineral Particles as little combined into larger ones as may be.

V

I have hitherto given an Account of the good and bad success, I have had, in attempting to preserve the Virtue of Chalybeate Waters, by Mechanical Contrivances, without putting any ingredient into them. I shall now mention other means which I made use of, which proved more effectual, *viz.* by dropping in of Acid Spirits, which are frequently prescribed by Physicians, to be taken with Chalybeate Waters, in such Forms and Proportions as they think proper; and that often to the great Benefit of their Patients. They are also frequently used to check the too great Ferment of Wine or Cyder,

Cyder, by burning Brimstone in the Casks, whereby they are impregnated with true Oil of Sulphur.

But as I have no Intention to intrude into the Physicians Province for which I am no ways qualified; so my present purpose is only, to give an Account of the Effects, which different numbers of Drops of these acid Spirits had on different Chalybeate Waters; in order thereby to find out the least number of Drops, that will suffice to keep their Mineral Particles, in so attenuated a state, as will prevent their precipitating to the Bottom and Sides of Vessels: leaving it to Physicians to determine as to the wholesomeness of them, as also in what Cases and Proportions such acidulated Waters are to be drank.

I am obliged to Sir *Conrad Sprengell* for the following Observation on Steel-Waters, as also for some other Improvements and Amendments which he made on the perusal of these Papers, viz. “ Steel-Waters contain a subtile Acid, by which as a Medium the Iron Ore is made soluble and united with the Waters. Alcalies by destroying that subtile Acid, destroy the Bond of Union betwixt the Waters and their Ingredients. Now the Question is, how
to

“ to preserve this vitriolick Acid, no doubt
“ by an Addition of something like it, and
“ yet the Acid should not prevail, because
“ then the Galls and other Astringents will
“ give no Colour to the Waters; in the
“ manner as any inky Writing may be ef-
“ faced by Lemon Juice, Spirit of Vitriol,
“ &c. Hence no black Tincture can be
“ produced with Galls, but when the Iron
“ is predominant. Green Vitriol makes Ink
“ only by its Iron, hence the Colours in Steel-
“ Waters, and from no other parts of the
“ Vitriol, for blue Vitriol makes no Ink.
“ Oil and Spirit of Vitriol change Iron into
“ Vitriol; but with this Difference that Oil
“ put upon Filings of Iron, changes them
“ into white, and Spirit into green Vitriol.
“ Vitriol is a Sal Medium form'd of an acid
“ and ferrugineous Substance which makes
“ green Vitriol, but the blue is compounded
“ of Copper.”

As the acid Spirits here made use of,
were not always the same, but bought at
different Places, by my self and others, who
made Experiments with them; so those who
shall think fit to repeat any of these Ex-
periments hereafter, may perhaps find some
little variation, of a Drop or so, of the quan-

tity that will do. What I here often mention as Oil of Sulphur, and which was bought for such; was not probably true Oil of Sulphur, but what is commonly sold for such, *viz.* sometimes Oil of Vitriol mixed with Water, or sometimes Spirit of Vitriol, it being difficult to procure true Oil of Sulphur.

Mr. Boyle Godfrey, the Chymist in his *Miscellaneous Experiments and Observations*, p. 136. cautions against the use of Oil of Vitriol, as being a more metallick Acid than the true Spirit of Vitriol: But as what is commonly sold for Spirit of Vitriol, is, he says, Oil of Vitriol mixed with Water; and that if Oil of Vitriol is ever used, one third less of it, than of the Spirit of Vitriol will do; hence we see the great uncertainty there is, as to the Strength of these acid Spirits.

Gas Sulphuris might be used for this purpose, which is Water strongly impregnated with the Fumes of burning Brimstone, in a large Receiver; but some look on this as a poor sour Water, and as the quantity of Spirit of Sulphur, in each Preparation of it, would probably be very different; accordingly different quantities of the *Gas* would also be requisite, in order to adjust the due proportion that would suffice to preserve the Virtue of Steel-Water with it. I

I was obliged to Mr. *Hooker* of *Tunbridge* for putting me on the research, to find out the smallest number of Drops of Oil of Sulphur, that would effectually preserve the mineral Particles of Chalybeate Waters from precipitating; in which he had made some progress, and recommended to me the farther pursuit of it. For, as he observes, if some of these Waters shall require so many of these acid Drops, as shall be thought to make Water too acid to be drank in any quantity; that Acidity may easily be wholly taken away, by dropping in, a little time before the Water is drank, a few Drops of Oil of Tartar, which by seizing on and combining with the acid Spirit, will form a wholesome neutral Salt. And the Mineral Particles of the Water, being thereby disseized of the acid Spirit, are set at liberty, to act almost as effectually, as before the acid Spirit was dropped in, as appears by the fine Tincture it will then give with Galls, if the Galls are first put in.

July 22d, Mr. *Hooker* set two *Florence* Flasks full of *Tunbridge-Wells* Water on a Gravel Walk in very hot Sun-shine, from ten in the Morning till seven in the Evening, having first put three Drops of Oil of Sulphur into one of the Flasks. At three

in the Afternoon, he found the Water heated to that degree, that he could scarce bear to hold the Flasks in his Hands: The Air-Bubbles were continually rising. The Water without any acid Spirit in it, was turbid, and had deposited much Ocre, and gave no tincture with Galls. The other with the Oil of Sulphur was transparent, and had a mineral ferrugineous Smell: Upon putting one eighth of a Grain of Galls to a Pint of it, it very slowly changed to a pale Purple; but on dropping in one Drop of Oil of Tartar, it instantly gave as deep a colour as fresh Water at the Spring, and with one Drop more, a deeper Purple than he ever saw in fresh Water with the same quantity of Galls.

In order to find out the least number of Drops of acid Spirit that would preserve unprecipitated the mineral Particles of this Water, I desired the Reverend Mr. *Wilson* Rector of *Walbrook* Church in *London*, to provide six very clean Quart Bottles; into which as soon as filled at *Tunbridge-Wells*, he dropped into Numb. 1. two drops of Oil of Sulphur. Numb. 2. three Drops. Numb. 3. four Drops. Numb. 4. five Drops. Numb. 5. six Drops. And Numb. 6. eight Drops. After these Bottles being corked, had stood an Hour,

Hour, to give time for the acid Spirit to diffuse it self uniformly thro' the whole Water; he then filled six equally sized Vials, with Water out of each Quart Bottle, and put equal quantities of powdered Gall into each Vial, and corked them: After standing an Hour, Number 1. was tinged of a light blue Colour; but none of the other five were in the least tinged.

Hence we see that three Drops of Oil of Sulphur in Numb. 2. so effectually seize on and lock up the mineral Particles of this Water, that they cannot be so acted on by Galls as to produce any Tincture: But when a little Oil of Tartar is added, which seizes on the acid Spirit, so as to cause it to let go its hold of the mineral Particles, which it kept attenuated and suspended, then they are at liberty to tinge with Galls, or to unite into so gross Combinations, as causes them to precipitate in the form of Ocre.

These Experiments were made the beginning of *August*, and the seventh of *August* in the next Year, the Weather Temperate, I procured by the favour of a Friend, three wine Quarts of *Tunbridge-Wells* Water. The Bottle Numb. 1. had three Drops of Oil of Sulphur. Numb. 2. had four Drops. And Numb. 3. had five Drops. These I received

at *Teddington, August* the fifteenth: When Numb. 1. gave with Galls, only a strong blue Tincture, which was heightened with Oil of Tartar, to a reddish Tincture; it had a manifest Sediment at the bottom, but no cloudy Flocks or Thrumbs; hence three Drops of Oil of Sulphur are not sufficient to preserve it good for so short a time; notwithstanding that number of Drops was found sufficient, so effectually to lock up the mineral Particles, as totally to extinguish the tinging Virtue of this Water with Galls.

Neither will four Drops be sufficient to keep it good long; for tho' *August* the 15th it had little or no Sediment, and gave a stronger blue Tincture than Numb. 1. which was heightened with Oil of Tartar to a good reddish Purple, at which time I poured off a Pint of it, the better to preserve it; yet *August* the twenty-first, there was some Sediment in the Pint, and it gave a somewhat weaker Tincture, than it did *August* the fifteenth. And *August* the thirtieth there was much more Sediment, and also a proportionably weaker Tincture.

But the Water of the Bottle Numb. 3. which had five acid Drops in it, gave *August* the fifteenth a much stronger blue Tincture
with

with Galls than Numb. 2. which was heightened with Oil of Tartar, to so deep a reddish Purple, that was hardly transparent. *August* the twenty-first the remainder of the Bottle gave also a deep Tincture. A Pint of this bottled, which was filled from it *August* the fifteenth had no Sediment *August* the thirtieth, and gave as strong a Purple as at first; it gave also a good Tincture *September* the twenty-fifth; And tho' this Pint stood not full from that time to *January* the eleventh, yet there was no Sediment, and it gave a blue with Galls, and with the addition of Oil of Tartar a fine reddish Tincture; which redness is increased by the Salt in the Oil of Tartar, in the same manner as the Salt of *Aquafortis* heightens the colour of Cochineel in the scarlet Dye, and as Nitre also heightens the redness of Blood. Hence we see that five Drops of Oil of Sulphur to a Quart, are sufficient to preserve the Virtue of this Water long. But as this number of Drops make it considerably acidulated, tho' not so much as to be disagreeable, yet, if more than should be, in drinking any considerable quantity of this Water, this Acidity may be abated by adding any proportion of fair Water; or may be wholly taken away, by two or three Drops of Oil of Tartar.

It is observable that in keeping this Water so long as to *January*, its Acidity was so much abated that it was scarcely to be tasted.

It seems probable, that if tubulated Corks were used with Bottles of this thus acidulated Water, they would not only contribute to preserve the Water the better ; but there might also be this further convenience, that the Virtue of some of these Waters, might also be thus preserved with fewer Drops. For I often observed, on the *Cobham*-Water thus acidulated with the fewest Drops that would do ; that it kept much longer and better when the Bottles were full, than when, by being but half full, a broader surface of the Water was exposed to the influence of the Air.

Whereas *Tunbridge-Wells* Water required three Drops of Oil of Sulphur, totally to extinguish its tinging Virtue with Galls. One Drop of that acid Spirit will have the same effect on the abovementioned Steel-Water of *Cobham* near *Claremont* in *Surrey*: And three Drops will as effectually preserve the mineral Virtue of that Water for two or three Months, when carried to distant Places to be drank, as that of *Tunbridge* is preserved with five Drops. This difference seems to be principally owing to the different quantities of Chalybeate, and
other

other calcarious matter which these Waters contain For *Bath* Water, which is found to contain, on evaporation to dryness, eleven and a quarter Grains weight of saline, nitrous, sulphureous, and principally calcarious matter to a Pint; by absorbing much of the acid Spirit of Sulphur, requires eight Drops of Oil of Sulphur to extinguish its tinging quality with Galls.

And even this number of Drops does not make it sensibly acid, after standing some time, tho' somewhat harsher; the Acid being absorbed by the great quantity of calcarious matter: And a fewer number of Drops as four or five, are not in the least to be perceived, after a few Days. I have also observed of several other Chalybeate Waters, which have had no more than an agreeable degree of acidity given them, that it has in a good measure gone off after some Weeks standing.

October the fifth, I received at *Teddington*, some Bottles of *Bath* Water, which had severally in them from one to eight Drops of Oil of Sulphur, when I put powdered Galls into Vials full of the Water of each Bottle. They all gave a blush, except that with one Drop, and another with no Drop in it, both which were not sensibly altered in Colour.
The

The Blush of the other seven was stronger and stronger, in proportion to the number of Drops of Oil of Sulphur, which was in the respective Water. But it did not exhibit this Blush seven Days after, which was fourteen Days from the time the Bottles were filled at *Bath*.

And whereas such acid Drops do effectually prevent the precipitation of the mineral Particles, which in other Steel Waters are apt to precipitate; I could perceive no sensible difference at the bottom of those Bottles, which had eight Drops in them, and those which had none: Whence it is probable that this Water deposits no Sediment, unless by standing very long. The small quantity of Sulphur which is in it, seems to be prevented from precipitating, by its uniting its self with the great quantity of calcarious matter in that Water; as is probable from Dr. *Guidott's* Experiments and Observations.

The Chalybeate Water near the Corn-Mill at *Bramshott* in *Hampshire*, has its tinging Virtue extinguished with three Drops. The Chalybeate Water at *Coffe's*-Mill near *Midhurst*, *Sussex*, requires five Drops.

Sunning-Hill Water has never four Grains of dry Residuum in a Pound; and with four Drops

Drops of Oil of Vitriol to a quart, retained its Virtue of tinging with Galls, for fifty Days at the Spring-Head. This Sediment does not melt in standing many Days, an Argument that there is little saline in it.

But the Sediment of the Steel-Water near Sir *William Abdy's* in the Parish of *Chobham* in *Surrey*, which is near equal in quantity with that of *Sunning-Hill*, rises in drying, in broad Alum-like Blisters; which had a mild saline Taste. Native Nitre is known to be alkaline and to rise in Blisters like Alum, and has no sign of acidity before it is exposed to the Fire, and has always a mixture of common-Salt. Most Chalybeate Waters have some nitrous Salt, and those which have most of it, are esteemed the best.

I found on two different Trials, little more than a Grain of yellow Ocry Sediment, in a Pound Avoirdupoise of *Cobham* Steel-Water, when evaporated to dryness; nor did it melt in standing many Days, a sign that there is little saline in it; yet this Water, as most Spring Waters do, gives white Clouds with a solution of Silver; a sign of some Salt.

This

This Water seems to have little else in it besides the Chalybeate Matter. Its great purity seems to be owing to its springing out of a pure whitish Sand, from a Hill which is all Gravel to its surface; in which circumstances the Springs of purest Water are observed to rise; four instances of which I have given, in my *Statical Essays*, Vol. II. p. 240, &c.

Mr. *Hooker*, having at *Tunbridge Town*, cut two clean *Florence* Flasks to a wide Orifice, and then weighed them, he poured into each of them a Pound Avoirdupoise of *Tunbridge* mineral Water: which being very carefully and slowly evaporated away in ten Hours, he weighed the Flasks the next morning, and found they were increased in weight two Grains and a quarter; which being therefore the weight of the Sediment in that quantity of Water, shows it to be a very pure Water: This was done the 26th of *January* in a very rainy Season; and yet the Water gave as good a Tincture with Galls as in a dryer Season. This Sediment did not melt into a Liquor, but was soft in standing some Days in the inverted Flasks, an Argument that there is some Degree of Salt in it; which might also probably be discovered, by dropping a few Drops of Solution of Silver in that Water.

Water. The Reverend Mr. *Wilson* found but a Grain and half of Sediment, on evaporating away a like Quantity of it, at *Tunbridge-Wells* in the beginning of *August*.

Philippus Ludovicus de Presseux, in his *Dissertatio Medica Inauguralis* 1736, says that he procured by evaporation to dryness, from seven Pounds of the *Geronsterre* Water at *Spa*, eight Grains of an Alkaline Salt, and ten Grains of Ocre. If this be the whole Sediment in so large a quantity of this Water, then its mineral Virtue might probably be preserved from precipitating, with very few Drops of acid Spirit.

And that the greater or lesser quantity of Oil of Sulphur, requisite to extinguish the tinging Virtue of any Steel-Water, depends on the proportion of the quantity and quality of the calcarious or other mineral matter in the Water, is further evident from hence, *viz.* That upon having put a little powdered Whiting into the *Cobham* Water, it then required no less than eight Drops of Oil of Sulphur, to extinguish its tinging Virtue: And then gave a very deep untransparent Tincture.

Hence also we may see, that the strength and goodness of a Chalybeate Water, cannot be judged of by the deepness of its Tincture

with Galls, as some are apt to imagine. Thus the Water at *Coffe's*-Mill gives a deeper Tincture, than any I ever saw, but withal requires more Oil of Sulphur, than the very pure *Cobham* Water; viz. Five Drops to extinguish its tinging Virtue, whence it is probable that it would have more Sediment on evaporation, which I omitted doing.

Dr. *Nesbit* found that *Islington* Water required nine or ten Drops of Oil of Sulphur to extinguish its tinging Virtue, a probable Argument that it has a good deal of Sediment on evaporation.

And as *Pyremont* Water has twenty two Grains of Sediment, in a Pound of it evaporated to dryness; and the Water of the *Caroline* Baths in *Germany* no less than thirty Grains; they would probably require many Drops of this acid Spirit to extinguish their tinging Virtue. And it is observable both in *Pyremont* and *Bath* Waters, that the Tincture of them with Galls soon precipitates much Sediment, the astringent quality of the Galls combining their mineral Particles into so large a size, as causes them to precipitate; whereas the Tinctures of purer Steel-Waters stand very long without precipitating.

It

It seems therefore reasonable, in order to judge of the comparative strength of Chalybeate Waters, not only to compare the different strength of their several Tinctures, but also their respective quantity of Sediment on evaporation to dryness: These Circumstances added to what may be learnt, by Experience of the effects they have on those who drink them, may serve the better to judge of their different strengths.

There is another ingenious method, to find the comparative strength of Chalybeate Waters, proposed by Mr. *Alexander Monro*, Professor of Anatomy in the University of *Edinburgh*, which is mentioned in the medical Essays and Observations, published by a Society in *Edinburgh*. Vol. III. 1735. viz.

“ He observes that Writers on this subject have contented themselves with telling us, that such Waters strike red, purple, violet or black Colours, when Galls or such other Astringents are mixed with them; and some have said that the deepest Colour shews the greatest proportion of Steel.

“ To satisfy himself of the truth of this, he dissolved artificial *Sal Martis*, in a small quantity of Fountain Water; then dropping few or more Drops of the Solution, in

“ to a given quantity of common Water,
“ he found that by the mixture of the Tinc-
“ ture of Galls, he could form all the diffe-
“ rent Colours mentioned; the larger quanti-
“ ty of the Solution always requiring the
“ greater number of the Drops of the Tinc-
“ ture to bring it to all the Colour it would
“ take; and that being as constantly deeper
“ than the others, where fewer Drops of
“ each had been employed.

“ *Sal Martis* being made with four Ounces
“ of Spirit of Wine, to two Ounces of Oil
“ of Vitriol, kept together in an Iron Pan till
“ they shoot into Cryftals the proportion of
“ Steel, in the artificial Salt or Vitriol of Iron,
“ is very little more than one third part.
“ One hundred and forty two Drops of the
“ Solution of *Sal Martis* in common Water,
“ weighed two Drams, therefore every such
“ Drop contained $\frac{1}{25}$ of a Grain of Salt, or
“ $\frac{1}{75}$ of a Grain of Steel.

“ Let the Glaffes be nearly of the fame fize
“ and thicknefs; to make a comparifon then
“ of any Chalybeate Water with this Solution,
“ into a determinate quantity of fuch Water,
“ pour Drop after Drop of a ftrong clear
“ Tincture of Galls, allowing a fufficient time
“ between each Drop, for its having its full ef-
“ fect,

“fect, till it is observed, that the addition of
 “more Tincture makes no change in the
 “colour of the Water : And to make sure
 “of the number of Drops of the Tincture
 “that are requisite, let the Experiment be re-
 “peated several times.

“Then having the same quantity of com-
 “mon Water in a like Glass, drop into it
 “the above discovered number of Drops of
 “the same Tincture of Galis, and mix them
 “well ; after which in the same cautious
 “manner, drop in the Solution Drop by Drop,
 “till their Colour is the same, with that of
 “the mineral Water.

“When once the quantity of Solution, e-
 “qual to the Contents of the *Spa* is known,
 “pour a due proportion of it, into common
 “Water ; and let several People examine,
 “whether the Taste of it is not the same,
 “with what the mineral Water has. He
 “has made, he says, Fountain Water so like
 “to several Chalybeate Waters, that none
 “could distinguish them.”

The purer the Watry Vehicle of any Steel-
 Water is, doubtless so much the better, provided
 there be enough of the Chalybeate Virtue. I
 have not observed this Steel-Water of *Cob-*
ham to be the weaker for much Rain. And

I am credibly inform'd that an eminent Physician, who had made many Observations on *Tunbridge Waters*, thought them stronger in wet than dry Weather ; which may be occasioned by the Waters passing thro' some Chalybeate *Strata* in wet Weather, which they do not rise to in dry Weather.

Some who have come directly from drinking the *Tunbridge Waters* to those near *Claremont*, thought the former considerably the stronger. Yet several who have drank these, during the few Years they have been opened, have found much Benefit by them. Half a Pint of them, has in *January* given me a fine glowing warmth all over ; on the motion of trotting my Horse soon after, as also several other Times on walking, not slow. And they have been found to heat some Constitutions too much. There is doubtless a great difference in the Qualities and Strength of mineral Waters, for some of them are more Chalybeate than others ; Some approach nearer to Vitriol, and many of them have much nitrous Salt mixed with them ; whence the great difference of these Waters.

And as there are doubtless a great variety of Degrees of Strength, among the many different Steel-Springs ; some of which are, as I
have

have heard, absolutely too strong to be drank; and others of various different degrees of strength; so are there likewise variety of Cases in our Constitutions, which require very different degrees of strength, in the Steel-Waters which are drank. Of which, Physicians are the proper and best Judges.

I cannot think, that the number of these salutary Springs is confined only to three or four, of the innumerable Many that kind Providence has blessed us with. But where there is a *Best*, Mankind are apt by a Foible observable in this as well as many other instances in Life, to slight all others as good for nothing.

I have my self found all the Benefit from this Water, that I think my Constitution is capable of, from any *Regimen* whatsoever.

I shall here insert a Letter on this Subject, which Dr. *Jurin* favoured me with, while these Papers were printing, *viz.*

REVEREND SIR,

“ **H**AD I either known sooner of your
 “ Design, or been a little more at
 “ Leisure since I was appris’d of it, I should
 “ readily have communicated to you such
 “ Observations of mine upon Chalybeate Wa-
 “ ters, as might have been of any service.

But I am now so straitned for time, that
“ I shall send you nothing more than what
“ relates immediately to the Subject of those
“ Papers you gave me the perusal of.

“ I have often observed, as you have done,
“ that when the tinging quality of *Tun-*
“ *bridge*, or other Chalybeate Waters, has
“ been suspended by putting a little of an
“ acid Spirit into them, their tinge has been
“ immediately restored upon the addition of
“ *Sal Tartari*, or any like Alkalious Salt. But
“ then the Tinge has been so different from
“ that bright blewish purple, that arises from
“ the Waters in their natural state upon
“ putting in Galls, green Thea, or any of
“ the like astringent Substances, being ra-
“ ther of a foul, dark reddish purple, than
“ a bright blewish one; That I have never
“ ventur’d to recommend such a Composition
“ of the natural Water, the Acid and Alkali
“ join’d together, to be drunk in the room
“ of the Waters alone; such a manifest dif-
“ ference in their tinging qualities giving
“ reason to suspect that their effects upon a
“ human Body might also be very different.
“ However, if any one should think proper
“ to recommend, or to drink them in the
“ manner you propose, as those two Salts
“ added

“ added together will compose a neutral Salt,
“ I shall not condemn the Practice, this be-
“ ing a Matter which Experience alone can
“ justly decide.

“ But when the Acid alone is proposed
“ to be added to the Waters, the Case is
“ greatly different. There are many dis-
“ eases, in which an Acid is directed by
“ Physicians, to be taken with Chalybeate
“ Waters, either as an addition to their Ef-
“ ficacy, or to make them pass off more rea-
“ dily by Urine. And the quantity of A-
“ cid Spirit directed to be taken in a single
“ Glass of Water, is generally more than
“ what will suffice to preserve a Quart of
“ them almost for any length of time, and
“ in carriage to any distance.

“ In this Case therefore we need not be
“ solicitous about finding the least quanti-
“ ty of Acid that will preserve the Wa-
“ ter, which, as you observe, is extremely
“ difficult, by reason of the different Strength
“ of those Acid Spirits which go under the
“ same Denomination ; but such a quantity
“ of Acid may be put into the Bottle be-
“ fore it be fill'd, as for instance, 20 or 30
“ Drops of *Elixir Vitrioli Mynsichti*, as will
“ be sufficient to keep the Water clear, and
“ not

“ not be too much for the Patient to take.
“ After this manner I have for many Years
“ directed the *Islington* Waters to be taken
“ by such Patients, as could not convenient-
“ ly drink them at the Well, particularly
“ the poor People in Mr. *Guy's* Hospital,
“ for whose use I obtained leave of the
“ Proprietor of the Well to fill as many Bot-
“ tles as I had occasion for, which I sent for
“ once or twice a Week, and they con-
“ stantly kept good from one time of send-
“ ing to the next; though, without the A-
“ cid, those Waters fill'd in the Morning
“ and brought to Town, will be foul in an
“ Hour or two, and good for nothing.

“ Among the Diseases in which the Cha-
“ lybeate Waters thus acidulated are highly
“ beneficial, I cannot, for publick good, for-
“ bear mentioning that obstinate Distemper
“ the Diabetes, in which they succeed to
“ admiration, when used for common Drink
“ to about three Pints or two Quarts a
“ day. They take off the Thirst, abate
“ the feverish Heat, and after a few days
“ the Urine begins to return to its natural
“ quantity, smell and taste, though for two
“ or three days, upon first drinking them,
“ the quantity of Urine will something in-
“ crease,

“crease, as might naturally be expected from
 “so diuretick a Liquor before its astringency
 “has begun to take place. But before the
 “Patient enters upon this course he ought to
 “be gently purged with *Epsom* or *Stre-*
 “*tham* Water, with the addition of *Man-*
 “*na* and *Sal Mirabile Glauberi*, two or three
 “times at such intervals as his weakness may
 “require.

I am,

Sir,

Austin-Fryars,

March 5, 1738-9.

Your most Obedient,

Humble Servant,

JAMES JURIN,

To conclude, we are not to depend wholly on natural Causes, as if the Mineral Waters, which Nature has produced in Plenty and Profusion every where, would by their mere natural Efficacy cure us. We must also earnestly apply our selves to the great Author and Fountain of Life. *For Man doth not live by Bread only, but by every Word that proceedeth out of the Mouth of the Lord doth Man live. Deut. viii. 3.* Excellent is the Advice of the Son of *Syrach* : Honour a Physician with the Honour due unto him, for the uses which you may have of him ; for the Lord bath

bath created him; the Lord hath created Medicines out of the Earth, and he that is wise will not abhor them, and with such doth he heal Men, and taketh away their Pains. My Son, says he, in thy Sickness be not negligent, but pray unto the Lord, and he will make thee whole. Leave off from Sin, and order thy Hands aright, and cleanse thy Heart from all Wickedness; give a sweet Savor and Memorial of fine Flower; then give place to the Physician. There is a time when in their hands there is good Success; for they also shall pray unto the Lord, that he would prosper that which they give for Ease and Remedy to prolong Life. Ecclus. xxxviii. 1, &c.

A
PROPOSAL

FOR
Cleaning away Mud, &c.

WHERE

Waters have a Stream or Current.

A
P R O P O S A L
F O R

Cleanſing away Mud, &c.

W H E R E

Waters have a Stream or Current.

IT is well known that foul Muddy Waters carry along with them a conſiderable quantity of Mud, &c. which they are apt to depoſite in great quantities, eſpecially in places, where by reaſon of the frequent return of Tides, it has more time to depoſite its Sediment; by reaſon of its ſometimes ſtagnant, ſometimes flow and contrary Motion; as in the Mouths of Rivers, that are not rapid, in Harbours, and Reſervoirs, which are filled by the Tides.

Now, if Water can by any means be made conſiderably more Muddy, in flowing out of, than into ſuch places; thoſe places muſt conſequently be gradually cleanſed of ſome of their Mud, in proportion to the greater degree of muddineſs of the Water when they flow out, than when they flow in.

And

And this I think may be effected in a good measure by the following Means, *viz.* by keeping the Mud well stirred, while the Stream is flowing out of the place ; by means of large Rakes, linked at the ends to each other, and drawn by Horses : Which Rakes must have one, two, or three Rows of Teeth, nearer or further off from each other, according to the different degree of stiffness or softness of the Mud. And if these Teeth stand as high out, on the upper as on the lower Side of the Rakes ; then when the Horses turn to go back along the same Stream, the Rakes being thereby turned over, the Teeth which were uppermost, being then become the lowest, will take place and stir up the Mud.

And these Rakes may be drawn, either farther from or nearer to the Shores, as shall be required, by various means, *viz.* By the Horses on either side going for some space, before or behind the others, or when the Horses can only go on one side ; by having them fixed to different Ropes of different lengths, as occasion shall require. And sometimes by fixing, either before or behind, or both before and behind, as occasion shall require, broad pieces of Wood edgewise, which
by

by running obliquely into the Mud, might turn the Rakes, in the same manner as Rudders do Ships; whereby their progressive Motions would be, not according, to the direction of the drawing Rope, but in the desired course.

• By these and the like means, great quantities of Mud might be stirred up, and carried off by the Water; and that, without any great Expence: considering the Advantage, it might in many cases be of, in cleansing off of Mud.

Trials might at least be made, in some of the more commodious Places for the purpose; whence a better Judgment might be made, as to the probability of success. Neither should we be discouraged, if Matters do not at first answer our Expectation: It is from repeated Trials and Observations, that we are to hope to make successful Improvements, in new Attempts; which are often baffled and laughed out of countenance, by incompetent Judges; who fancy they show their deep Judgment and Penetration, in slighting and rejecting Attempts, which at first may prove unsuccessful: But which an unwearied Diligence and Perseverance might

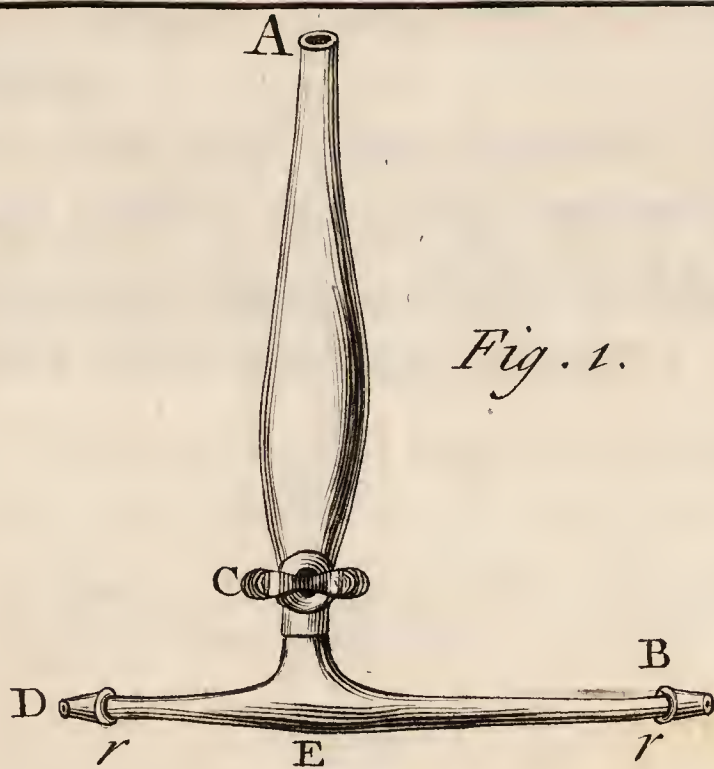
M

make

make effectual, to the great Benefit and Advantage of Mankind.

There would be no great Expence in making a few Tryals of this sort, in commodious places for the purpose; which I am persuaded would be found to carry off such Quantities of Mud, as would encourage the farther Prosecution of it.

And we have good Encouragement to make some Attempts in this way, from the Success that the Inhabitants of *Damascus* find in cleansing their many muddy Rivulets, *viz*, by putting a great Bough of a Tree into the Water, and fastening to it a Yoke of Oxen; Upon the Bough there sits a good weighty Fellow, to press it down to the Bottom, and to drive the Oxen: in this manner the Bough is dragged all along the Channels, which are thereby cleansed. See *Mr. Maundrell's Journey from Aleppo to Jerusalem*. Now a well-contrived Rake would not only require less force to draw it than large Boughs of Trees, but would also more effectually raise and stir up the Mud than Boughs could do. And possibly there may be some Cases, in which it might be of service, to have either very long or broad Harrow-like Rakes, moved briskly to and fro, by the large Cranks of
Water-



Place this Plate at the end of the Book.



Water-Wheels, fixed in steddily-anchored or moored Barges, or elfewhere as occafion may require.

I have here only given a general Hint, which may poffibly be farther improved, by fome of the many ingenious Mafters in Mechanics, with which this Age abounds.

THE END.

A GENERAL

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A GENERAL

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